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ATLAS 60" Fording Study

Contract No. DAAK70-91-C-0041

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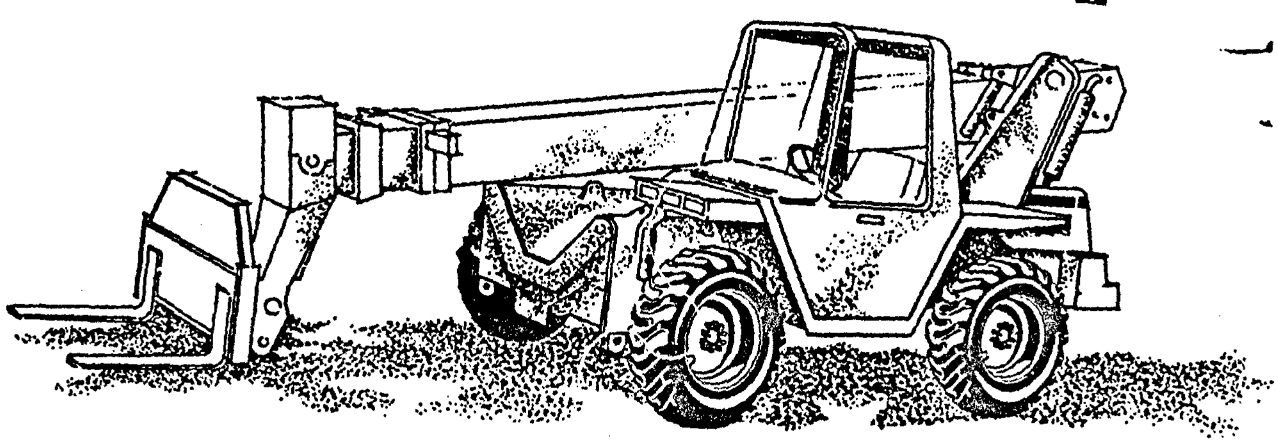
March 3, 1992



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ATLAS Fording Study
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Executive Summary

The All-Terrain, Articulated Lift System (ATLAS) is the next generation of rough-terrain, shooting boom, fork-lift trucks. ATLAS operational requirements call for a dash speed of 50 mph, 60 inches of seawater fording capability for Logistics-Over-the-Shore (LOTS) operations, 10,000 lbs lift capacity at 4 feet and 4,000 lbs lift capacity at 21.5 feet and enhanced operator controls.

For ATLAS to reach the procurement phase, production and operating costs must be managed wisely. Machine requirements beyond those available on commercial rough-terrain fork-lifts must be weighed against their incremental costs. The ATLAS's 60" fording requirement is substantially beyond commercial vehicle capability and was thought to be a major cost driver. To address this issue, BRDEC awarded Caterpillar a contract to study the impact of adding the 60" fording capability to a commercial machine conceptually altered to fulfill the operational requirements of ATLAS (Figure 1).

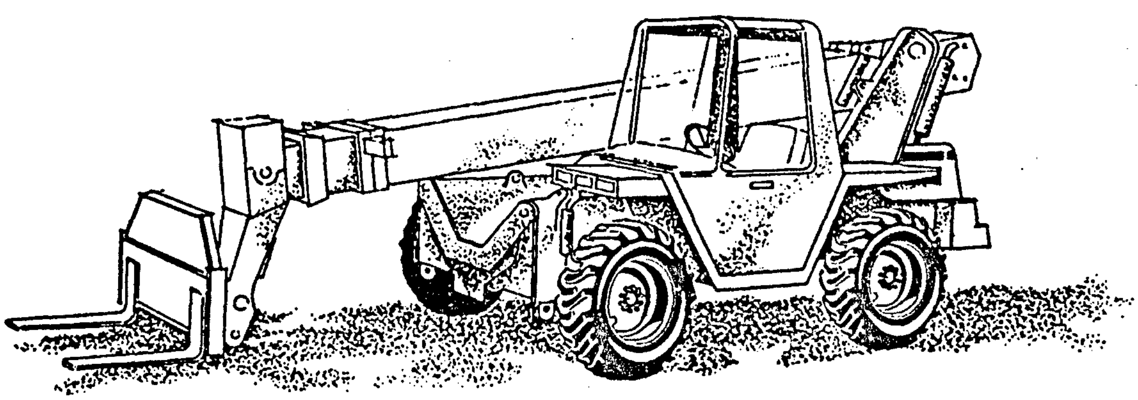


Figure 1 All-Terrain, Articulated Lift System (ATLAS) vehicle

Under the technical direction of Mr. David Krawchuk, Material Handling and Equipment Team (MHE), Fort Belvoir, VA, Caterpillar Inc. performed the ATLAS 60" Fording Study. The information generated during that effort is reported in this report. As a result of this study, the total technical and costs risks were substantially reduced without compromising ATLAS operational requirements.

The RFP and the work plan submitted in the Caterpillar proposal was heavily focused on the impact of saltwater corrosion. The concern was that protecting the vehicle from saltwater corrosion would require extreme measures (like the use of stainless steel materials, etc). That would drive procurement and operating costs, and adversely impact maintainability, reliability, and overall machine life. The impact of the 60" fording requirement on ATLAS operational performance was also investigated.

An intense Failure Modes, Effects and Criticality Analysis (FMECA) was proposed to assess the impact of seawater corrosion on all major vehicle systems and system components. However, early contract effort identified a cost-effective coating (primer) that substantially eliminates the corrosion problem. This information eliminated the need for the intense FMECA effort and more effort was shifted to other fording issues. This shift in effort allowed a more complete definition of an affordable ATLAS vehicle.

This study predicts that the procurement cost drivers (Figure 2) for an ATLAS vehicle are as follows:

- *50% will be the cost of commercial machine*
- *40% will be the cost of increasing speed from 20 to 50 mph*
- *10% will be the cost of 60" of fording.*

The 10% cost growth associated with the 60" fording requirement is based on the use of a very corrosion resistant primer coating identifed during this contract.

The commercial machine provides a fording capability of 16" and nominal corrosion resistance. A fording requirement of 30" would drive 80% of the cost required to provide a fording depth of 60".

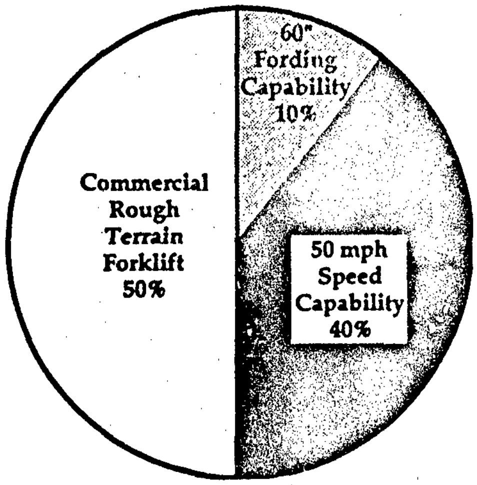


Figure 2 Procurement Cost Drivers

Technical issues required to safely and reliably operate ATLAS in 60 inches of salt water for extended periods of time fall into 2 categories: 1) waterproofing and 2) corrosion. These issues were further complicated by the fact that 60% of the vehicle could be under water during fording operations.

First, the ATLAS must be designed to be waterproof to the required fording depth. Classical waterproofing techniques, waterproof components, sealing, venting breather lines, etc., will satisfy that requirement..

Second, the LOTS operation requires that ATLAS be designed with sufficient corrosion protection to operate safely and reliably in a saltwater environment a number of times during its life cycle. The extensive and repetitive exposure of ATLAS to this environment necessitates that the corrosion issues be resolved in a thorough yet cost effective manner. As a result, corrosion and corrosion control was the prime focus of the trade study to assure that ATLAS would be as capable and reliable in completing its final mission as its initial mission.

The All Terrain Lifter, Articulated System (ATLAS) 60" Fording Study identified:

1) A cost-effective coating that substantially mitigates the life cycle costs associated with corrosion, and

2) The technical viability of ATLAS to safely and reliably operate in 60 inches of salt water for LOTS operations.

Besides addressing the primary concerns of fording and corrosion, the study also identified and resolved the following concerns:

1) C130 Transportability
2) NBC Contamination of Hydraulic System
3) Surf Zone Stability
4) Concept Design of Waterproof Operator Cab
5) Viability of FMTV Engine.

Corrosion Resistance Coating

The coating technology presented in Attachment 1 identifies an extra-ordinary, zinc-rich primer that is corrosion resistant and compatible with the CARC topcoat. Other primers that provide the required corrosion resistance were not compatible with CARC. CARC primers currently in use by the Army do not exhibit the desired corrosion resistance required by LOTS operations. This extra-ordinary, zinc-rich coating will provide the desired corrosion resistance without compromising the desired NBC protection associated with CARC. It eliminates the need for exotic designs, materials, and processes and allows the use of cost effective, off-the-shelf technology. This primer technology minimizes procurement, and owning and operating costs' impact of providing ATLAS the desired seawater corrosion resistance.

As a result of identifying this coating technology, the technical direction of this study shifted part of its emphasis from corrosion to the aforementioned engineering issues. Results of these investigations are presented in the following paragraphs.

C130 Transportability Study

The C130 Transportability Study (Attachment 3) identified one approach for transporting that does not compromise ATLAS operational, speed, lift, and mobility requirements. It requires that the wheels be reversed with the rim-offset inboard to meet the C130 requirement of 102 inches width.

This approach permits a wider stance and the use of large, 20.5R25, tires to fulfill its mission yet be readily converted to a C130 transport configuration. Caterpillar identified an axle, tire, and offset-rim design that meets those requirements. Alternate designs may be considered with maturation of ATLAS.

NBC Contamination of the Hydraulic System

The NBC Contamination of the Hydraulic System investigation (Attachment 4) identified cost effective technology to eliminate contamination of the hydraulic reservoir, lines, valves, and cylinders.

Hydraulic systems require an open breather or vent to the atmosphere to provide make-up air for the hydraulic tank. This repetitious inhaling and exhausting of air concentrates contaminates in the hydraulic oil during operations. The contaminated oil then contaminates the hydraulic lines, valves, cylinders, etc. of the system.

By substituting a simple bladder in lieu of a breather on the hydraulic tank, a closed system can be used (Figure 3).

The concept eliminates contamination of the hydraulic oil and subsequent disposal of a hazardous waste.

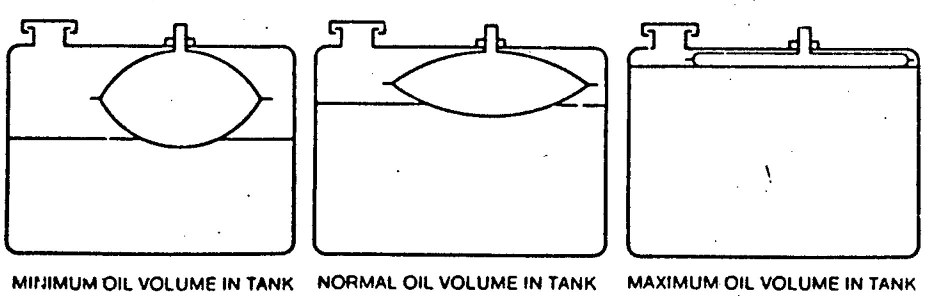


Figure 3 Hydraulic tank with bladder

Surf Zone Stability Assessment

The Surf Zone Stability Assessment (Attachment 2) defines the stability of ATLAS when operating in a surf zone.

Operating within a surf zone introduces a wave loading not typically considered in classical stability assessments. This wave load on the rear of the vehicle is of greatest concern when ATLAS carries a 10,000 lb. load above the 60" waterline.

The Surf Zone Stability Assessment established that the ATLAS could safely and reliably operate in and exit from a surf zone while carrying the load above the waterline without tipping. This analysis identifies parameters that may be monitored as the ATLAS matures, assuring that this stability is not compromised. A more rigorous surf zone stability assessment, considering buoyancy effects, is suggested during full scale development.

Water-Proof Cab

The water-proof cab (Paragraph 3.0) provides the operator a safe, functional environment for LOTS operations in a variety of water/air temperature extremes (Figure 4).

The concept incorporates a watertight structure below the waterline by locating the operator access entirely above the waterline. Operator access would be via a "gull-wing" door. The operator would be able to enter or leave the vehicle without entering the water or swamping the cab.

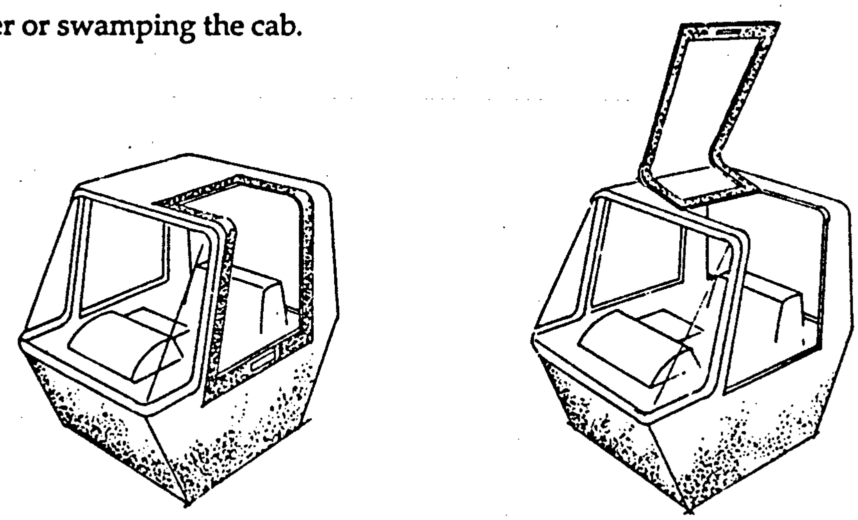


Figure 4 Water-proof cab with gull-wing door

This concept precluded further consideration of an alternative design that raised the cab above the waterline. That alternative design would have required removing the cab for C130 transport. The water-proof cab ensures the survivability of the operator during LOTS operations in a NBC contaminated environment. (Water degrades the level of protection provided by the NBC suits.)

FMTV Engine

The Family of Medium Tactical Vehicles (FMTV) Engine (Paragraph 2.0) was considered for ATLAS because it is a modern engine being used by the Army (Figure 5). Its use would substantially reduces life-cycle costs as well as reduce program technical risk. The FMTV engine and engine accessories have demonstrated fording capability as well as having fulfilled the RAM-D requirements for the FMTV Program.

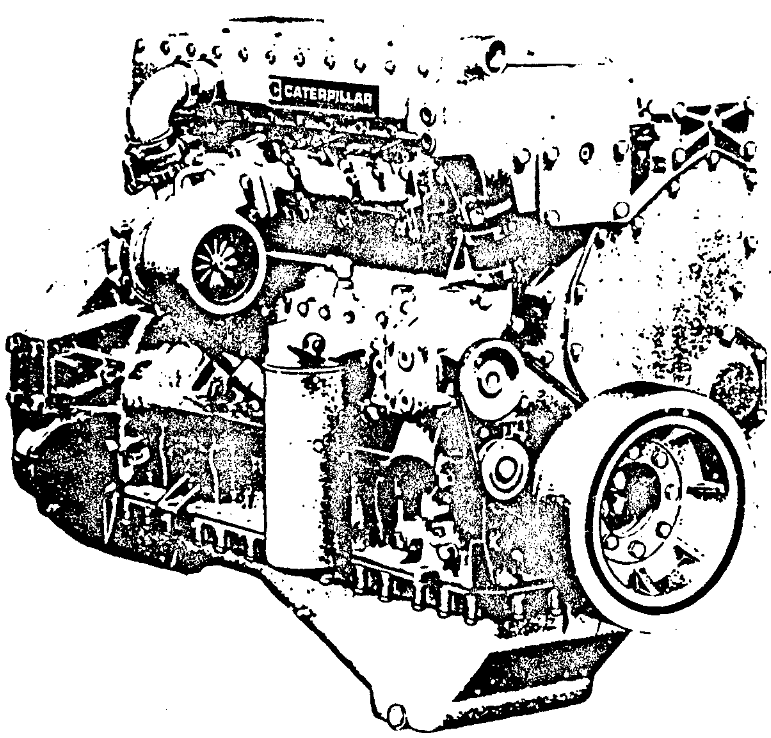


Figure 5 Caterpillar 3116 Family of Medium Tactical Vehicles (FMTV) Engine

ATLAS Subsystems

The impact of fording and corrosion was also considered on the following ATLAS subsystems:

Electrical Arrangement	*Paragraph 4.0*
Instrument Group	*Paragraph 4.0*
Transmission	*Paragraph 6.0*
Axles	*Paragraph 6.0*
Suspension	*Paragraph 5.0*
Chassis	*Paragraph 8.0*
Boom	*Paragraph 9.0*
Micro-Climate Control	*Paragraph 11.0*
Closed Circuit Television	*Paragraph 13.0*

For each subsystem, technology was identified that permitted ATLAS to be operated and maintained in a safe and effective manner. The study addressed *performance, human factors, safety, reliability, producibility, cost growth, and integrated logistic support* issues.

Each of these issues are addressed within each ATLAS subsystem paragraph. The following summary identifies the principal subsystems that are impacted by each issue.

Performance requirements for capacity, weight (total and distribution), fuel consumption, speed, vehicle height, and ground clearance are achievable by implementing the engine, powertrain, suspension, transportability, and cab concepts that are presented later. ATLAS performance will be most influenced by the C130 transportability issue, in particular tire size and vehicle gage.

HFE/Safety requirements for operator effectiveness and operator/spectator safety and noise are achievable. Suspension, cab, micro-climate control, and closed-circuit television (CCTV) concepts have the greatest impact.

Reliability requirements of 89.9% for an 8 hour mission, and Mean-Time-Between-Mission-Failures are achievable by incorporating commercial water-proof components and the corrosion resistant coating. Establishing the acceptability of the FMTV engine and engine accessories substantially reduced ATLAS reliability risks.

Producibility requirements are addressed within each section. Implementation of the coating technology, permits application of commercially available water-proof components including the FMTV engine and engine accessories. The water-proof cab/structures including the implementation of bulkhead (electrical, hydraulic, etc.) connectors provides a manufacturable structure and assembly with minimum cost growth. Engineering changes that would influence producibility are required to minimize crevice volume and facilitate decontamination are equally applicable to minimizing the incidence of crevice corrosion.

Procurement *Cost* Estimate, as represented by Figure 6, establishes that roughly 50% of the ATLAS cost is incurred to obtain a commercial rough terrain forklift capability.

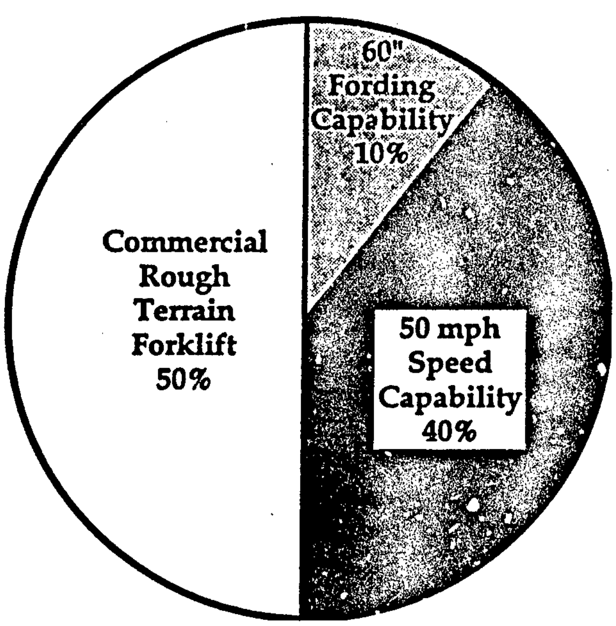


Figure 6 Procurement Cost Estimate

ATLAS cost growth, above and beyond a commercial rough-terrain, shooting boom forklift truck, would be largely the result of the speed requirement. The speed requirement over 35 mph necessitates a new engine, powertrain, axles, tires, and most notably an elastic suspension. Forty percent of the procurement cost is incurred to provide for the high speed operation. Implementation of the coating technology minimizes the cost growth associated with the selection and processing of corrosion resistant materials. In combination with commercially available water-proof components, the cost growth to provide the fording capability is projected at 10% of the procurement costs. Most notably, only 10% of the cost is incurred to fulfill the 60 inch fording requirement. Of the fording costs almost 80% of that cost is incurred to obtain a 30" seawater fording depth capability. The remaining twenty percent of the cost is driven by increasing the fording depth to 60".

ILS requirements for 95% Achieved Availability and Maintainability including repair/ echelon, Direct Productive Annual Maintenance Hours (DPAMMHRS), support equipment, and preventative maintenance have been assessed within each section. Daily, fresh-water washdowns and proper maintenance of the corrosion-resistant coating provides sufficient corrosion control during LOTS operations. Only components that are subject to erosion corrosion must be inspected and replaced as required. DPAMMHRS increased as expected with the level of complexity of the ATLAS vehicle subsystems and operation in a corrosive environment. Systems that contribute to this increase include suspension, micro-cooling, and CCTV.

Paragraph 1.0
Vehicle System

1.1 Baseline Description

1.1.1 Commercial Applications of Rough Terrain Fork Lift Trucks (RTFL). The use of variable-reach rough terrain lift trucks has grown rapidly over the past decade. Telescoping material handlers (TMH), "Shooting booms" or "reach trucks" now represent between 40-50% of total rough terrain lift truck sales in North America. The remainder are of the "vertical mast" configuration.

One of the biggest advantages of a shooting boom machine over a vertical mast lift truck is its ability to reach forward and place the load. A straight mast truck must drive right up to the scaffolding or building to place the load; a telescopic machine can reach over obstacles to get the job done. Since lift height decreases as reach increases, the combination of required placing height and reach must be taken into account when specifying a RTFLs for a particular job.

The frame leveling feature of RTFLs (Rough Terrain Fork Lifts) improves their productivity and stability over straight mast lift trucks. The operator can level the chassis on uneven terrain for greater lateral stability and safety during high lifts. With frame leveling, RTFLs machines retain more capacity during high lifts than comparable-capacity high reach trucks.

RTFLs all-wheel three mode steering provides excellent maneuverability for greater productivity on crowded job sites. For example, the circle steering mode gives Caterpillar's RT100 a very tight 13.6 ft (4.1 m) outside turning radius.

Compact dimensions allow RTFLs to operate in low overhead and confined areas, further enhancing their productivity. For example, Cat's RT100 is only 104 in (2640 mm) tall and 96 in (2440 mm) wide.

Users buy four-wheel drive machines when they expect extremely poor underfoot conditions or need exceptional gradeability. RTFLs allow contractors to start building earlier in the spring and continue working in the worst underfoot conditions. Attachment flexibility makes these machines much more than just a "forklift". An attachment coupler makes it easy to drop off the fork carriage and install a truss boom, loose material bucket or other attachment for added versatility on the job site. This versatility increases machine utilization and can help justify premium rental rates.

1.1.1.1 Features of the Reference (Caterpillar RT100) Vehicle.

- Strong frame resists distortion and cracking in tough applications.
- Durable CAT 3114 engine.
- Proven CAT powershift transmission with elcetronic controls, full-clutch modulation, precision-ground high contact ratio spur gears, anti-friction bearings, large capacity lube system and excellent cooling capacity for long transmission life.
- Outboard planetary axle design reduces stresses on differential, drive shafts and axle shaft U-joints.
- Enclosed oil disc brakes on both axles are protected from contamination and oil cooled for long brake life.
- Parking brake interlock prevents driving through parking brake to protect brake discs.
- Electro-hydraulic control system eliminates mechanical linkages and hydraulic lines for increased reliability.
- Electronic control box is designed to high CAT standards for trouble-free operation and long life. Heavy-duty box is located in iso-mounted cab to reduce vibration and to protect it from the elements for increased reliability.

- Premium wiring harness is waterproof and protected from abrasion for long, reliable service.
- Solenoid-actuated main control valve spools are enclosed within control valve body to seal out dirt and eliminate leaks.
- O-ring face seal fittings throughout hydraulic system reduce leaks.
- Lock valves are connected to cylinders with welded tubes to eliminate leaky fittings and hose failures.
- Overhead guard is certified to provide FOPS and ROPS protection. Standard 3 in (75 mm) wide seat belts pass the SAE J386 seat belt pull test.
- Gauges for engine coolant temperature, engine oil pressure and transmission oil temperature allow operator to monitor this critical information to help prevent damage to engine or transmission.
- Superior capacity retention at reach allows customers to place more material in less time. Optional outriggers increase capacity at reach for increased productivity.
- Planetary drive axles with full-time 4-WD, a front axle differential lock, equal size tires, balanced weight distribution and excellent ground clearance give these machines outstanding traction in difficult underfoot conditions to help keep jobs on schedule.
- All-wheel steering with three steering modes provides a very tight turning radius and excellent maneuverability.
- 12 degree of frame tilt allows operator to level chassis on uneven terrain to enhance lateral stability during high lifts.
- Attachment coupler on the boom allows attachments to be changed quickly and easily for versatility on the job. A wide range of attachments is available to meet customer's needs.

1.1.1.2 Operation and Maintenance/Parts Manuals. Commercial manuals are attached to clarify base vehicle configuration and operation/maintenance considerations.

Operation and Maintenance Manuals	*Attachment 6*
Parts Manuals	*Attachment 7*

1.2 Alternative Design Vehicle Configuration.

The ATLAS vehicle concept generated by this study (Figure 1.2-1 and 1.2-2) uses the Caterpillar RT100 as the base vehicle. The modifications are driven by either vehicle performance or the 60" fording requirements. A description of the concept follows.

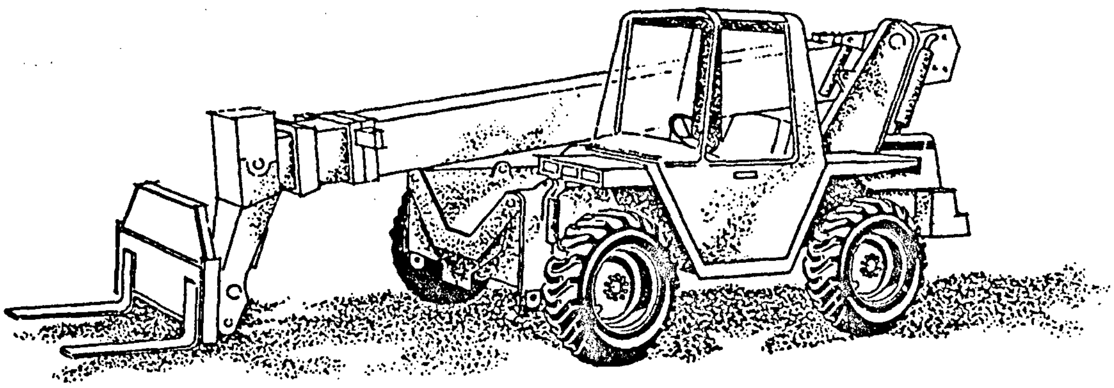


Figure 1.2-1 The ATLAS concept design fulfills all identified operational requirements.

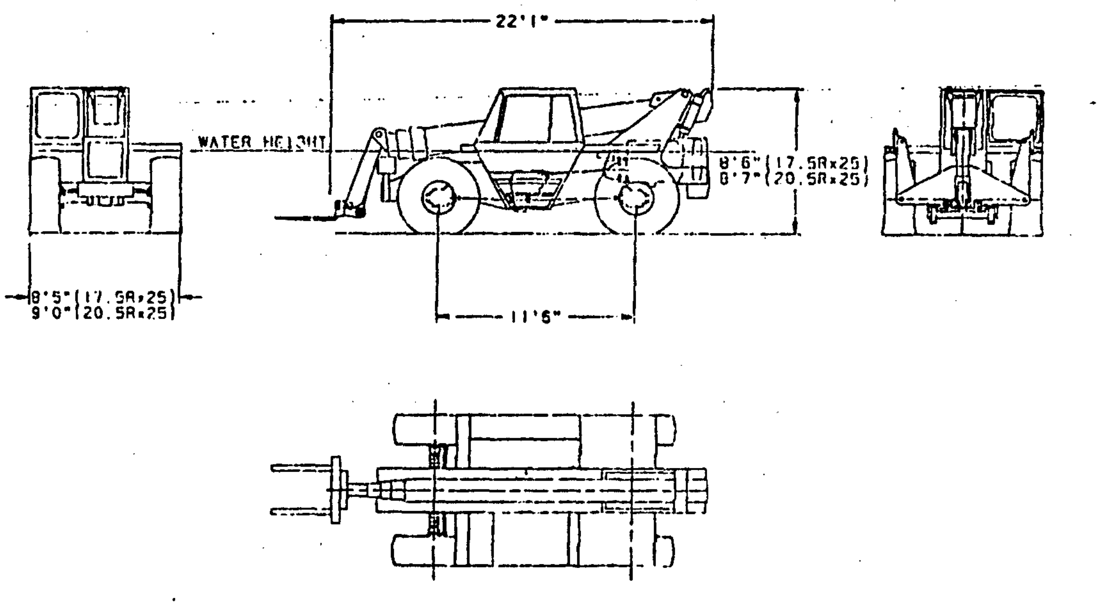


Figure 1.2-2 ATLAS vehicle general dimensions

1.2.1 Concept Development. The ATLAS concept was strongly influenced by four major developments:

a) Identification of a superior corrosion resistant coating,
b) A Waterproof cab concept,
c) Acceptability of Family of Medium Tactical Vehicles (FMTV) Engine for ATLAS, and
d) C130 Transport Mode Concept.

Technical uncertainties were identified and addressed as follows:

Corrosion Resistant Coating Technology	*Attachment 1*
Surf Zone Stability	*Attachment 2*
C130 Transportability Study	*Attachment 3*
NBC Contamination of Hydraulic System	*Attachment 4*

These studies provided the direction for generating the ATLAS vehicle concept. The concept vehicle will fulfill the operational requirements for:

a) Self Deployable at convoy speeds up to 50 mph,
b) Variable Reach,
c) Operational/fording capability to 60" (sea water) during Logistics Over the Shore (LOTS),
d) 10,000 lb capacity @ 4 feet and 4000 lbs @ 21.5 feet,
e) Micro-climate cooling system for operator in an enclosed cab,
f) Operator enhancements that provide for coordinated boom movements (single lever true horizontal and true vertical control),
g) Stability Monitoring and control,
h) Closed circuit television (CCTV) for viewing forks and right rear of the vehicle, and
i) C130 drive-on/drive-off capability with minimal disassembly and without removal of vehicle cab.

Definition of the following vehicle subsystems (arrangements) are strongly influenced by the previously defined ATLAS requirements:

a) Engine Arrangement,
b) Operator Compartment,
c) Micro-climate Control,
d) Electrical/CCTV/Instrumentation System,
e) Brake Arrangement,
f) Steering Arrangement,
g) Hydraulic Arrangement,
h) Transmission/Drive Shafts,
i) Drive Axles,
j) Frame Leveling,
k) Frame,
l) Boom,
m) Attachments, and
n) Tires.

1.2.2 Operational Considerations. Operational considerations required to provide a valid trade study include but are not limited to:

a) System Hour
b) % Operating Time in saltwater
c) Operating hour/year
d) Operational life
e) Reliability

a) System Hour. For purposes of this trade study, a system hour is defined as 80% operating time and 20% travel and transportation time. During the 48 minutes of operating time, the operator will complete 40 loading and transport cycles. The definition of the system hour defines the number of cycles/hour that the vehicle will be subjected to salt water.

b) % Operating Time in Saltwater. The vehicle will be subjected to 6 LOTS operations per year, each 24 hours in duration. During that time the vehicle will be operating in and out of the saltwater 80% of the time (19.2 hours).

The % Operating Time in Saltwater establishes the number of times that a vehicle will be subjected to a salt water environment per year.

c) Operating Hours. The vehicle will be subjected to a total of 24 operations per year each 24 hours in duration for a total of 576 hours per year.

1.2.3 100 Hour Operation. A histogram for 100 hours of operation was developed to establish a baseline for sizing the automotive elements of ATLAS. The operational modes are defined as follows:

	% Operation
Accordian Effect	*5%*
Convoy	*25%*
Work Cycle	*60%*
Idle	*10%*

1.2.3.1 Accordion Effect. The accordian effect is defined as the lengthening and compression of a convoy. Some vehicles will not maintain convoy speed and lengthen the convoy. Those vehicles must have sufficient dash speed to overtake the convoy within a prescribed period of time or progress of the convoy is reduced.

The aforementioned ATLAS Histogram projects that the 50 mph dash speed will be used 5% of the time (5% out of 100 hrs of operation). This ATLAS concept provides for a maximum speed of 50 mph on level, improved surface roads with an empty machine.

1.2.3.2 Convoy Speed. ATLAS will be deployed in convoys with 2.5 and 5 ton trucks. ATLAS must maintain a minimum speed over a variety of grades without compromising convoy progress. Typically, convoys speeds are less than the dash speed. When convoying, the ATLAS will be unladened or empty. The convoy speed drives ATLAS powertrain requirements beyond commercial RTFLs which are matched to a maximum speed requirement of 35 mph.

Convoying will be 25% of ATLAS's mission. Here is the predicted convoy histogram:

25% <	*2 hr*	*— 35 mi/hr*	*— 2% Grade*	*— Empty*
	3 hr	*— 35 mi/hr*	*— 1% Grade*	*— Empty*
	20 hr	*— 35 mi/hr*	*— 0% Grade*	*— Empty*

<u>1.2.3.3 Work Cycle.</u> The ATLAS work cycle is typical for RTFLs, i.e. low speed operation over undulating, unimproved surfaces, and severe grades. Typically, the RTFL is carrying a load more than 50% of the time because of the lower operating speed during the loaded part of the work cycle. However, for purposes of this study, loaded and unloaded time was assumed to be equal during the work cycle

The work cycle portion of ATLAS's mission is 60%. The histogram for the work cycles is predicted to be:

60% <	*1/2 hr*	*≥ 2 mi/hr*	— *45% Grade*	—	*1/2 Empty* / *1/2 Loaded*
	1 hr	*≥ 2 mi/hr*	— *30% Grade*	—	*1/2 Empty* / *1/2 Loaded*
	3-1/2 hr	*≥ 2 mi/hr*	— *15% Grade*	—	*1/2 Empty* / *1/2 Loaded*
	55 hr	*≥ 2 mi/hr*	— *0% Grade*	—	*1/2 Empty* / *1/2 Loaded*

<u>1.2.3.4 Idle.</u> A RTFL will idle a substantial portion of its duty cycle waiting for work. For ATLAS, idle time is predicted to be 10% or 10 hrs out of 100 hr mission.

10% *10 hr* — *idle*

<u>1.2.3.5. Operational Life.</u> The vehicle will have a projected 20 year service life.

1.2.4 Criticality Analysis. The ATLAS configuration defined in this study identified and mitigated a number of concerns with respect to fording and corrosion.

Operational safety hazards and mission critical failures were addressed by a concept including a water-proof cab, the proven FMTV engine (with fording capability), and implementation of classical, commercial practices for waterproofing construction equipment.

Maintenance safety hazards and basic failures were addressed primarily by the identification of a corrosion resistant coating, preventive maintenance recommendations, and a hydraulic system concept that prevents NBC contamination. Only the concept development of the C130 Transport modification introduces the potential for a maintenance safety hazard, i.e. reversal of the wheel/rim, if appropriate resources are not allocated to this task.

1.2.4.1 Definitions. The criticality analysis implemented the definitions and establishes an order of precedence for the study. For purposes of this trade study, mission hours (t) = 8 hours anticipated for a LOTS operation.

a) Operational Safety Hazard < *t, mission hours*
b) Mission Critical Failure < *t, mission hours*
c) Maintenance Safety Hazard > *t, mission hours*
d) Basic Failure > *t, mission hours*

1.2.4.1.1 Operational Safety Hazard. An operational safety hazard is defined as any combination of failure modes and effects that may result in a Category I or Category II hazard during any single LOTS operation, i.e. less than 8 hours of operation.

Category I hazards are defined at catastrophic, i.e. a failure which would cause death of a human being or complete system loss.

Category II hazards are defined as critical, i.e. a failure which may cause severe personal injury or major system damage resulting in the loss of the mission.

1.2.4.1.2 Mission Critical Failure. A mission critical failure is defined as any combination of failure modes and effects that may result in a component, subsystem, or system failure that would reduce the effectiveness of that vehicle during a LOTS operation by 20%. Preventative maintenance during that specific operation is not applicable.

1.2.4.1.3 Maintenance Safety Hazard. A maintenance safety hazard is defined as a combination of failure modes and effects that may result in a Category I or Category II hazard over a number of LOTS operations.

1.2.4.1.4 Basic Failure. A basic failure is defined as any combination of failure modes and effects that would reduce the Mean-Time-Between-Failure of a component or subsystem.

1.2.4.1.5 Preventative Maintenance. Establishing a preventive maintenance base line improves program efficiency and effectiveness. Increased preventive maintenance is required to maintain any vehicle subjected to a salt water environment. Preventive maintenance procedures included (but not limited to this category) are post operational wash and dry, increased inspection, maintaining protective coating, etc. General preventive maintenance procedures applicable to a variety of common part categories will be defined. For example, this initial effort may preclude serious consideration of a stainless steel vehicle.

1.2.4.1.5.1 Clean Water Washdown Recommendation. ATLAS will undergo a daily clean, fresh water washdown to preclude the unnecessary build up of salt on the vehicle.

The clean water washdown substantially reduced the corrosion of a track width mine plow developed for the USMC Assault Amphibious Vehicle (AAV). After a year of virtually constant exposure to a salt water and spray environment, no single component was replaced due to degradation as a result of corrosion.

The AAV Mine Plow (AAVMP) was subjected to extensive hours of operation in salt water and a salt spray environment. During the mine clearing demonstration, the AAV would make several excursions into the surf zone per day to remove sand from the plow and wait for the next mine clearing exercise. The AAVMP had only the protection afforded by a red-lead primer and commercial topcoat.

1.2.4.1.5.2 Maintenance of Corrosion Resistant Coating. The corrosion resistant primer and CARC top coat must be maintained consistent with the standard maintenance procedures of the U.S. Army.

1.2.4.1.5.3 Inspection and Replacement. Supplemental inspection and replacement (as required) of leaf springs will be required. Leaf springs will be installed on the rear axle in particular and may be installed on the front axle (similar to the ATLAS prototype vehicle).

1.3 Performance.

ATLAS performance both during LOTS operation and more conventional land operations is crucial to a mission success. ATLAS performance will not be compromised as a result of inclusion of a 60 inch fording requirement. Secondly, ATLAS performance will not improve as a result of reducing the fording requirement.

Specific performance attributes were considered throughout the study including:

Capacity
Weight (Total and Distribution)
Fuel Consumption
Speed
Vehicle Height
Ground Clearance

1.3.1 Capacity. ATLAS will have a variable reach capacity of 10,000 lb @ 4 feet and 4000 lbs @ 21.5 feet. No factors have been identified as a result of this study that would compromise the current nor matured lift and reach capacity of ATLAS.

1.3.2 Weight (Total and Distribution). The ATLAS weight and weight distribution must be considered in two modes, operational and C130 transport. The requirements of the two modes are somewhat conflicting. The operational mode requires a rear axle weight to be greater than front axle to facilitate lifting a maximum of 4000 lbs @ 21.5 feet, whereas the transport mode necessitates that the weight be balanced (to maximize the GVW) within axle weight limitations.

<u>1.3.2.1 Operational Mode.</u> The projected ATLAS configuration with GVW of 32,500 lbs. introduces no identifiable operational concerns but the GVW introduces a number of transport concerns that are addressed in the C130 Transportation Study.

<u>1.3.2.2 C130 Transportation Study.</u> An ATLAS transport configuration identified within Attachment 3 provides a temporary 3rd axle, removal and stowage of the counterweight on forks, and reversal of the rim/wheels to meet the weight distribution and envelop limitations of C130 transport.

1.3.3 Fuel Consumption. ATLAS fuel consumption for RTFL (low speed, low load factor) operations and convoy (high speed, high load factor) is strongly influenced by GVW, speed, grade, etc. Fuel tank size will be sufficient to allow completion of a 10 hour mission.

1.3.4 Speed. ATLAS shall be self-deployable at convoy speeds with a dash speed of 50 mph on level, improved surfaces. This speed requirement represents the most substantial departure from a commercial RTFL, establishes the requirements for the engine, transmission, axles, and tires, and requires a suspension group and a mechanically augmented front axle. Each element of the configuration is addressed within subsequent paragraphs.

1.3.5 Vehicle Height. The required ATLAS height of 101 inches facilitates C130 drive-on/drive-off capability without removal of vehicle cab. The cab concept, identified as a result of this study, eliminates or negates the concept of raising the cab above the water-line 60 inch fording requirement. The cab transport height will be maintained at 98-100 inches.

Given the stringent requirement for C130 transport, ATLAS height must be monitored and addressed throughout maturation of the design.

1.3.6 Ground Clearance. ATLAS requirements are defined as follows. ATLAS with and without load will be capable of negotiating a 25 degree ramp of length greater than the truck's wheelbase with level surfaces at both the top and bottom of the ramp. Nothing other than the tires shall come in contact with the ramp when ATLAS travels over the ramp in either direction. Hydraulic fittings, hoses, tubing, and linkages shall not be the lowest portion of the truck and shall be protected by structural members from striking obstacles.

ATLAS ground clearance is projected to be 18 inches with the 20.5Rx25 tires on the concept vehicle. The 20.5Rx25 provide an additional 2.0 inches of ground clearance over the 17.5Rx25 tires. Given the acceptability of the projected ground clearance, no concerns have been identified that would compromise the ground clearance of the ATLAS.

1.4 Human Factors Engineering/Safety Requirements.

A number of issues have been identified that impact the safe and reliable operation of ATLAS that are resolvable with the maturation of the ATLAS design.

Specific HFE/Safety elements considered are as follows:

Operator Effectiveness
Operator/Spectator Safety
Noise Operator/Spectator

1.4.1 Requirements. HFE and Safety requirements are derived from MIL-T-53038.

1.4.1.1 Human Factors Engineering. ATLAS characteristics with the waterproof cab will provide for operation and maintenance by personnel ranging from the small person clothed, through the large person arctic clothed, in accordance with SAE J833, SAE J925, and Mil-STD-1474.

1.4.1.2 Safety. ATLAS will meet the safety requirements specified in SAE J 98 and ANSI B56.6. All rotating and reciprocating parts and parts subject to high temperature shall be guarded when such parts are exposed to contact by the operator and maintenance personnel performing daily maintenance functions. Nonfunctional edges shall be rounded, projecting points shall be blunted or rounded and excessive length of fasteners shall be avoided. Steps and platforms for entering the forklift shall have anti-skid, ice resistant surfaces. Oil level indicators for engine, transmission, and other components will be within easy reach and safe access of the operator and maintenance personnel.

1.4.2 Operator Effectiveness. Operator effectiveness will be enhanced by a number of engineering concept developments including:

a) Suspension,
b) Micro-cooling, and
c) Closed Circuit Television (CCTV).

1.4.2.1 Suspension. ATLAS convoy and dash speed requirements establish the need for an elastic suspension. The effectiveness of the ATLAS suspension will be established with ride quality evaluations defined in Paragraph 5.0.

Maturation of the ATLAS design may require a suspended seat at vehicle speeds above 20 mph on improved surfaces.

1.4.2.2 Microcooling. The microcooling concept provides a subsystem that enhances the safety and performance of the ATLAS operator in harsh and life threatening environments. The objective of microcooling is to minimize water loss by the operator that would otherwise impair his judgment and reduce operational effectiveness jeopardizing operator and spectator safety. Thermo-electric cooling/heating devices will maintain operator effectiveness up to an ambient, temperature of 120 degrees Fahrenheit. Augmenting the thermo-electic system with an ice filled cooler enables ambient temperatures up to 160 degrees Fahrenheit.

1.4.2.3 CCTV. The CCTV concept designs provide for a two camera (monaural) subsystem that permits the operator, with his view obstructed, to effectively engage or place a load up to the full extension of the boom. The second camera provides a rearview from the vehicle to assist the operator in negotiate the vehicle in reverse in any of the three steering modes; two wheel, crab, and counter steer. Other government studies have established that a 2-dimensional system fulfills the requirements for the supplemental vision. The CCTV is projected to have a 3% duty cycle for ATLAS material handling operations.

1.4.5 Operator/Spectator Safety. As a result of this evaluation, no issue was identified that compromised the safety of the operator or spectator.

1.4.6 Noise Operator/Spectator. Operator and spectator noise limitations have been derived from MIL-T-53038 for:

a) Noise Limits- Operator,
b) Noise Limits-Spectator, and
c) Noise Hazard Precaution/Warning.

As a result of this evaluation, only noise emitted by the FMTV engine has been identified as a concern to be resolved during maturation of the ATLAS design.

<u>1.4.6.1 Noise Limits - Operator.</u> The noise produced by the ATLAS shall not exceed 85 db (A) at the operators station during lifting, load lowering, and high speed operation. The evaluation will be conducted under the following conditions: engine operated at 2/3 maximum no-load, governed speed, 2/3 the rated load, and all windows fully opened.

<u>1.4.6.2 Noise Limits - Spectator.</u> The noise level of the of the forklift (excluding horns) shall not exceed 88 db (A) when tested in accordance with SAE J88.

<u>1.4.6.3 Noise Hazard.</u> The precaution of MIL-STD-1474 and noise hazard warning signs will be provided if the noise level is 85 db (A) or greater.

<u>1.4.6.4 Noise Engine-FMTV.</u> The FMTV engine is relatively quiet for a 290 HP engine emitting 96.4 db (A) untreated and 94.3 db (A) treated.

1.4.7 ATLAS HFE/Safety Baseline. The baseline RT100 vehicle incorporates a number of commercial features that address operator safety, performance, and comfort as well as spectator safety. These features are listed below.

- Spacious operator compartment with plenty of head, leg, and elbow room comfortably accommodates most operators.
- Standard vinyl seat with thick cushions for comfort. Optional full-suspension seat for even greater operator comfort.
- Tilt steering column adjusts to fit the operator. Low effort power steering reduces operator fatigue.
- Low effort controls conveniently located to reduce reaching and operator fatigue.
- Electric joystick with low "Lever" effort gives the operator precise control of the boom.
- Twist-grip transmission control allows the operator to easily change gears or direction with the same control.

- Power brake system reduces brake pedal effort while maintaining good brake pedal "feel".

- A large convex mirror gives the operator good visibility to the right rear corner of the machine. The optional mirror group provides two additional mirrors to further enhance rearward visibility.

- Redesigned over-head grate offers improved upward visibility, and redesigned fuel/hydraulic tank module provides better visibility over right side of machine.

- Enclosed cab option with heater/defroster keeps operator warm in the winter, and good natural cross-ventilation keeps cab cool in the summer.

- Low noise levels and a radio/cassette option enhance operator comfort.

- Optional hydraulically-operated attachment coupler lets operator change attachments without leaving the cab.

1.5 Reliability.

Figure 1.5-1 provides a reliability nomograph that correlates reliability, MTBF, and mission duration (operating time on nomograph). This study incorporates "waterproof" not "water resistant" components to achieve the reliability requirements of ATLAS.

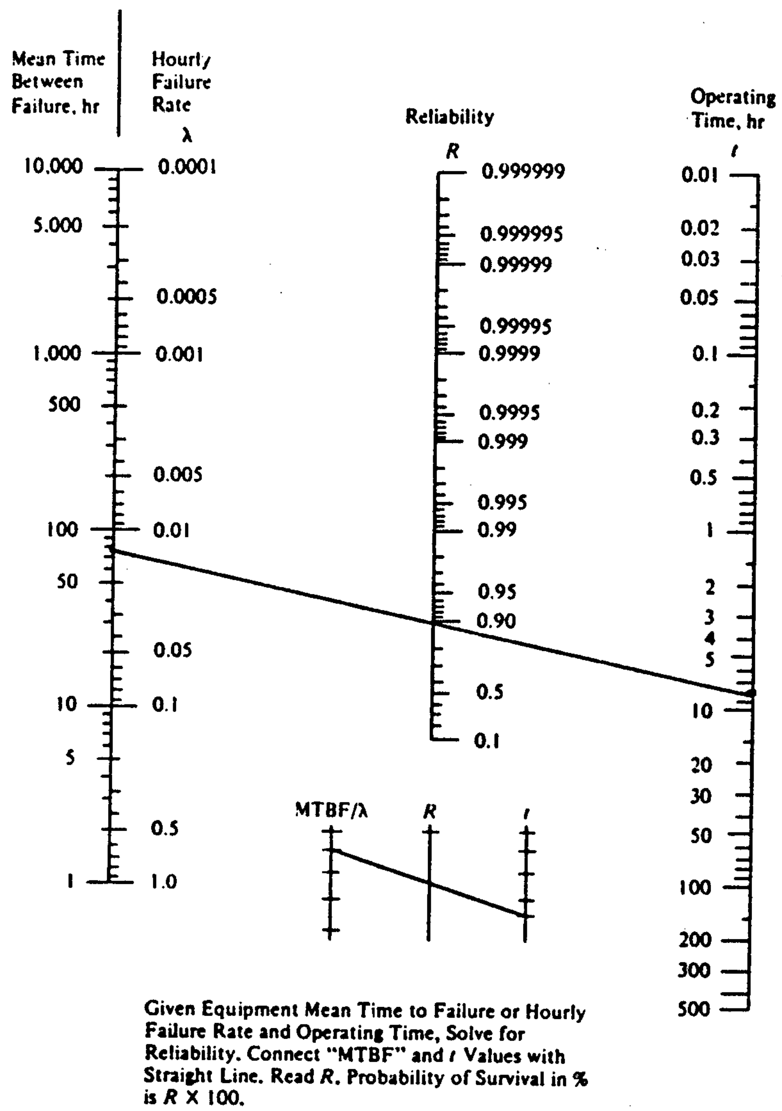


Figure 1.5 - 1 Reliability nomograph of the exponential failure distribution.

Reliability of the ATLAS vehicle was established based upon guidance provided in MIL-STD-785B Reliability Program for Systems and Equipment Development and Production. Specific reliability attributes (base line values) were established for the ATLAS vehicle as follows:

Reliability.........................89.9%
Mission Duration.................... 8 hours
Mean-Time-Between-Failures (MTBF)....76 hours

The reliability of 89.9% is a calculated term based upon a mission duration of 8 hours, a MTBF of 76 hour, and assuming an exponential failure rate implemented by the following equation:

% Reliability = e exp-(lambda summation)(mission duration)
89.9% = e exp-(0.0132)(8) or
89.9% = e exp-(1/76)(8)

1.5.1 Reliability Modeling and Allocations. Consistent with the guidance provided in MIL-STD-785 Tasks 201 and 202, the ATLAS vehicle is modeled as a series of subsystems with a specific reliability allocation for each subsystem . Typically automotive systems do not provide subsystem redundancy in order to minimize weight and maximize vehicle performance.

At the system level the ATLAS will exhibit a MTBF of 76 hours or a lambda summation of 0.0132 (= $MTBF^{-1}$ or 76^{-1}). The summation of the lambda for each subsystem cannot exceed 0.0132 and meet the reliability objectives. In summary, the reliability allocation for each subsystem the ATLAS vehicles is projected as follows:

Subsystem	*MTBF*	*lambda*
Engine Arrangement	500	0.0020
Operator Compartment	1 000	0.0010
Electrical/CCTV/Instrumentation	1 000	0.0010
Suspension/Steering	10 000	0.0001
Powertrain	1 000	0.0010
Hydraulic System	1 000	0.0010
Chassis	10 000	0.0001
Boom/End Effectors	10 000	0.0001
Tires	2 000	0.0005
Microclimate Control	4 000	0.0003
Subtotal		0.0063
Reserve		0.0069
	Total	0.0132

The reliability allocation provides substantial reserve (0.0069) that may be allocated to as yet undefined additional systems or added to currently defined systems. The reliability allocation is predicated upon the following assumptions:

a) The ATLAS vehicle is an extension of proven commercial RTFL tailored to the requirements of the US Army.

b) The ATLAS vehicle design reflects acceptable waterproofing technology, and

c) Preventative Maintenance procedures are implemented with respect to the protective coating and the engine and automotive elements.

1.5.2 Failure Modes. Operating a vehicle in a salt water environment introduces a number of potential failure modes or damage mechanisms that must be assessed. Resolution of this problem is required for safe and reliable operation. As noted previously, failure modes are very sensitive to the definition of the operational requirements and definition of the mission.

Each of the following failure modes have been assessed with respect to the appropriate design elements) in the following order of precedence including:

Electrical Short
Fluid Contamination
Air Restriction/Constriction
Galvanic Corrosion
Stress Corrosion
Crevice
Pitting
Erosion Corrosion
Uniform Corrosion
Intergranular
Selective Leaching

The first three failure modes, electrical short, fluid contamination, and air restriction/ constriction, can be eliminated with the use of off-the-shelf technology. This available technology will provide low-cost solutions for fording depth to 60".

The balance of the failure modes are related to vehicle operation in salt water for extended times over a period of years. Attachment 5 provides a brief, text book description of these corrosion mechanisms. Implementation of the corrosion resistant primer substantially mitigates the balance of the corrosion mechanisms.

Crevice corrosion must be addressed during the design maturation. Minimizing the number and size of crevice will adequately resolve this issue.

Erosion corrosion must be addressed by inspection and replacement as required of two elements of the ATLAS, leaf springs and drive shafts. These two elements are exposed to high, relative surface velocities in an abrasive, corrosive environment, i.e. sand/ saltwater. The abrasiveness of the environment precludes further consideration of surface treatments, exotic materials (stainless steel), etc.

1.5.2.1 Material Deterioration Prevention and Control. Caterpillar referenced the guidance provided in DARCOM-R 702-24 Army Corrosion Prevention and Control Program for this trade study.

1.6 Producibility.

As a result of this study, a corrosion resistant primer has been identified that substantially mitigates the long term degradation of ATLAS due to operating in a salt water (corrosive) environment. This primer is compatible with the MIL-P-26168 CARC paints. Reference Attachment 1.

Commercial manufacturing practices for RTFL would generally reflect the scope and depth of producibility considerations provided in MIL-HDBK-727 Design Guidance for Producibility. A number of special design considerations that impact producibility are required to accommodate the salt water fording requirements of the ATLAS vehicle. The design considerations fall within two broad categories of Watertight Integrity and Combating Corrosion.

1.6.1 Watertight Integrity. The watertight integrity of the ATLAS vehicle can be provided by the design of watertight compartments and the utilization of waterproof bulkhead connectors for electrical, hydraulic, and mechanical penetration points to the watertight compartments.

Commercial high density electrical connectors, as well as MIL-C-5015 connectors, are available to provide adequate resistance to electrical shorts.

1.6.2 Combating Corrosion. Several generic methods are available for combating corrosion. One method is simply the replacement of inexpensive parts. Another would be to include one or more of the following design features:

1) choosing one metal for a system or electrically insulating dissimilar metals,
2) using a large anode surface area of compared with the cathode surface area,
3) eliminating or reducing to a minimum crevices, lap joints, nuts and bolts, rivets, small recessed areas, grooves and scratches, etc.,
4) providing for easy maintenance to prevent buildup of dirt, scale, rust, etc.,
5) allowing for uniform and moderate flow rates of fluids,
6) using the proper material for the given environment,
7) reducing the stress in parts that may stress crack, and
8) using corrosion inhibitors, corrosion-preventing films, or coatings where necessary.

1.6.2.1 Alloying. Alloying frequently provides the prime path to obtaining desired corrosion performance of engineering materials, i.e. ferrous, cast irons, and aluminum.

Identification of the corrosion resistant coating effectively precluded further consideration of material changes, i.e. steel to stainless steel to provide the desired corrosion resistance.

1.6.2.2 Ferrous Materials. Stainless steels feature chromium, a particularly useful alloying metal for ferrous materials, (steel). When present in concentrations greater than 12%, a passive oxide film is formed that is very corrosion resistant.

Stainless steels are particularly sensitive to erosion, crevice corrosion, and chloride pitting.

1.6.2.3 Cast Irons. Cast irons, gray, malleable, and ductile, typically are alloyed with silicon in sufficient concentrations to provide a complex silicon-oxide film that imparts good corrosion resistance to cast iron.

1.6.2.4 Aluminum. Service experience with 1000, 3000, 5000, and 6000 series wrought aluminum alloys in marine applications under the condition of partial exposure to salt water environments demonstrates good corrosion resistance and long life.

1.6.3 Protective Coating. Protective coatings cover a tremendous range. Choice of coating is determined by the degree of corrosion resistance required and the relative cost of obtaining the desired corrosion resistance. Some of the common coating techniques are defined as follows:

- Chemical conversion - building up a relatively thick oxide film by anodizing (anodic oxidation, usually of aluminum) or immersing in a chromate or phosphate solution.

- Cladding - hot rolling a sandwich of two metals to obtain metallurgical bonding between them.

- Diffusion - high-temperature treatment in which one or more metals are dif fused into the substrate metal to form an alloy diffusion coating.

- Electroplating - Electroplating or electrodeposition of a metal such as chromium, nickel, copper, tin, zinc, cadmium*, gold silver or platinum provides a thin layer on a metal substrate. Typically restricted to chromium in RTFL applications, these coating are more noble (more corrosion resistant than steel in salt water). The coating must be free of pits, scratches, or imperfections that would otherwise expose the steel substrate to the corrosive environment. Exposure of the steel substrate to salt water forms a galvanic cell, introduces a pitting corrosion, and rapidly degrades the durability of that component.

  Hydraulic cylinder rods are typically electroplated to provide and maintain a smooth surface to maintain the integrity of the hydraulic seals. A minimum thickness of 0.016 inches is required to provide the necessary level of protection for ATLAS.

- Enameling - Enameling provides a fused glassy composition on the surface of steel or fuses a polymeric composition on a metal substrate to provide a non-corrosive film. Enameling is not typically used in off-highway applications.

- Flame spraying (or metallizing) - Metallizing provides an alternate manufacturing method to electrodeposition. Metallizing is achieved by blowing metal in finely divided form through a melting flame onto a metal substrate. Typically, the film would be more noble than the steel substrate and subject to similar considerations.

- Hot dipping - Hot dipping provides a protective film by immersing the metal substrates in liquid metals to coat them with zinc (as in galvanizing), tin, lead or aluminum. The coating may be more nobel (tin, lead, or aluminum) or less nobel (zinc) than the substrate.

- Painting - Painting provides a pigmented organic carrier that reacts with air or dries by evaporation.

* The use of cadmium has been restricted in the U. S. and EEC. Beginning in January, 1993 products that include cadmium will no longer be permissible or available.

1.6.4 Corrosion Design. Degradation due to corrosion can be minimized by implementing the following design strategies.

1.6.4.1 Bolts. Chrome plated bolts may be replaced by oil-and-phosphate coated bolts. Chrome plated bolts are sensitive to damage of the chrome plating, whereas the oil-and-phosphate bolts are less sensitive to corrosion of the substrate.

1.6.4.2 Sealing. Any component sensitive to water damage or corrosion, in particular, should be sealed to prevent the intrusion of water.

Structural box elements should be watertight. Provide plugs to enable draining any accumulated water.

1.6.4.3 Crevice Corrosion Resistance. The design of the vehicle should minimize or eliminate features that accumulate or retain water, dirt, oil, etc.

Drain holes should be provided in any cup-like features.

Intermittent welds should be eliminated and replaced by continuous welds.

Single sided welds should be replaced by double sided welds.

Perforated (skid) plate should be replaced by adhesive backed, skid-resistant overlays.

1.7 Cost Growth.

The ATLAS vehicle will reflect cost growth over a commercial vehicle.

The cost growth is associated with the performance requirements of the ATLAS, specifically the speed. The speed requires a suspension arrangement to control ride and shock when convoying. Alternately the suspension group must retain the stable platform and performance of a RTFL.

Given that the ATLAS vehicle fording requirements are driven by the LOTS operation, the cost growth associated with marinizing the vehicle are relatively independent of fording depth for this mission. Waterproofing the automotive elements and engine accessories eliminates salt spray from degrading critical elements. These elements are readily available largely due to historical US Army and USMC requirements for fording 60 inches of water.

Additional costs associated with the fording requirement are sealed cab and the corrosion resistance coating.

The fording, in combination with the NBC requirement drives the development of the unitized sealed cab. Given the extent to which water/moisture degrades the protection provided by the MOPP IV gear, elimination of the fording requirement may not preclude the desirability for a unitized sealed cab. The unitized cab would prevent salt water from readily entering the cab and coming into contact with the operator.

The corrosion resistant coating with the extra high density of zinc dust increases the material cost of the primer by a factor of two over standard MIL-P-22709 (which is a non-CARC primer). The necessity of the coating is driven by salt spray and not necessarily by fording depth.

1.8 Integrated Logistic Support.

For this study, the alternative design (as required for the baseline vehicle to meet ATLAS requirements) was analyzed for Integrated Logistic Support (ILS) requirements. RAM-D related concerns were surfaced along with any provisioning issues. The maintainability requirements, listed in MIL-T-53038, served as a baseline to measure against maintainability.

1.8.1 The major ILS related concerns are trade-offs required to provide proper corrosion resistance, modifications necessary to meet ATLAS road speed and changes required to meet the 60" fording requirement. At the start of this study, it was felt that corrosion resistance was a major concern. Corrosion concerns were greatly reduced when a suitable corrosion inhibitive primer was found. The area which currently has the greatest ILS impact is the road speed requirement. Modifications for increased speed have large potential effects on reliability and maintainability. The 60" fording requirement, which has its largest impact on cab design, has some reliability and maintainability concerns, but these are relatively small in relation to the road speed requirement.

1.8.2 Specific Integrated Logistic considerations (definitions included) are:

Reliability

Availability

Maintainability
Repair Echelon/Skill Required
MTTR (Direct Productive Annual
Maintenance Manhours)
Support Equipment
Preventative Maintenance

"*Reliability*" is defined as the probability that a system will perform satisfactorily for a given period of time, when used under specific operating conditions.

"*Maintainability*" will analyze requirements for both preventative and corrective maintenance.

"Repair echelon" will use organizational/intermediate/depot levels in analysis of the net effect of a FMECA failure on operational availability. The analysis will look at the net increase in maintenance manhours (DPAMMHRS) resulting from modifying the system.

The *"MTTR"* is the mean time spent to repair a failure, regardless of level of maintenance.
"Support equipment", as a factor, is the logistic burden of systems necessary to maintain the modified equipment in a functional condition.

"Preventative maintenance" will analyze the increased requirements to maintain the modified vehicle in good working order. This procedure will include, but is not limited to, post operational wash and dry, increased inspection and maintenance of protective coating.

"Availability" is defined as Achieved Availability (Ai) of 95%. The system factors which impact on the ability to reach this goal are the limiting areas for availability.

Paragraph 2.0
Engine Arrangement

2.1 Baseline Description-Engine.

The engine in the reference vehicle (RT100) is a state of the art turbocharged diesel engine. It is the 4-cylinder version of Caterpillar's 1.1 liters/cylinder engine series.

In October, 1991, the 6-cylinder version of this engine was selected by the Army for its new generation of Medium Tactical Trucks. The key features of this 1.1 Series are common through the series.

Details of the reference vehicle's 4-cylinder version, known as Caterpillar's 3114 engine (Table 2.1-1), are provided to establish the level of technology available with the 1.1 Series and more specifically in commercial RTFLs.

Key benefits of Caterpillar's 1.1 Series engine are exceptional performance, proven reliability and durability, low fuel consumption and quiet operation.

	CAT 3114	
Configuration	*In-Line, Four Cylinder*	
Bore	*4.12 in*	*(105 mm)*
Stroke	*5.00 in*	*(127 mm)*
Displacement	*268 cu in*	*(4.4 L)*
Horsepower @ 2200 rpm	*103 hp*	*(77 kW)*
Peak Torque @ 1400 rpm	*284 lb-ft*	*(385 N•m)*
Governed speed (no load)	*2420 rpm*	

Table 2.1-1 CAT 3114 Specifications

2.1.1 Reliability. One of the main reasons for the 3114's outstanding reliability and durability is that the engine in the RT100 operates at a conservative speed and low load factor, well below its maximum 150 hp (112 kW) @ 2600 rpm capability.

2.1.2 Lube and Cooling Systems. The large capacity lubrication and cooling systems also enhance engine durability. The 11.6 qt (11.0 L) lube system has a large plate-type oil cooler integrally mounted in the engine block to reduce oil deterioration and varnishing of precision parts in severe operating conditions. The gear-type oil pump is mounted low, in the oil pan, for quick priming to reduce engine wear during start-up. A feature especially important in RTFL applications, since the engine is started frequently. A bypass valve in the oil filter mounting base ensures engine lubrication during cold starts and in case the filter plugs.

The 32.0 qt (30.0 L) capacity cooling system has a large five row radiator, and a 21 in (533 mm) diameter, six-blade fan for excellent cooling. The fan draws cool air from the rear of the vehicle for improved cooling efficiency. Flat fins in the radiator core reduce clogging and ease radiator cleaning. Wing nuts on the rear grill provide easy access for cleaning the radiator. The water pump is mounted separate from the fan and fan drive which reduces load and vibration for longer bearing and seal life. It is driven from the crank pulley by a separate belt to isolate it from an accessory belt failure.

2.1.3 Intake and Exhaust Systems. A large capacity, dual element air cleaner with pre-cleaner and service indicator is standard. The pre-cleaner and service indicator extend filter element life. The secondary element protects the engine in case of primary element failure for increased engine durability.

The turbocharger, driven by the engine's exhaust, acts as a compressor to boost the intake system pressure and force more air into the cylinders. This increases power while improving fuel economy and reducing emissions. The exhaust manifold has short straight runners to conserve exhaust energy for the turbo thus improving engine efficiency. The modern split turbocharger housing is designed for maximum performance. The turbo's size is carefully matched to the engine's power rating for optimum fuel economy and performance. The turbocharger allows the 3114 to produce rated horsepower and torque up to 7200 ft (2200 m) altitude. A large muffler and a cover over the engine oil pan contribute to lower noise levels.

2.1.4 Fuel System. The 3114's excellent fuel economy is the result of precise fuel metering, high pressure direct injection and an advanced combustion chamber design. During endurance and quality tests, average RT100 fuel consumption was between 1.0 and 2.0 gallons per hour (3.6-7.6 L/h). Actual fuel consumption will depend on the vehicle application and other load factors.

Cat's 1.1 Series uses a unit injector fuel system. This eliminates external high pressure fuel lines for increased reliability. The mechanical unit fuel injectors combine the injector nozzle and high pressure pump into one assembly for each cylinder. This rugged system provides very high injection pressures and short injection times for fast response, low fuel consumption and excellent emissions control. An electric solenoid on the flyweight-type, full range governor shuts down the engine when the engine run control is turned off.

Spin-on primary and secondary fuel filters keep contamination out of the fuel system for top performance. The primary fuel filter screens out large particles and also acts as a water separator. It can be cleaned and reused. The secondary filter has a medium to filter out fine particles, so it must be replaced periodically. A primer pump makes it easy to prime the fuel system.

2.2 Alternative Design.

ATLAS power requirements were calculated based on operational requirements. Dash speed and convoying scenarios identified the minimum power requirement as 270 hp. The Army's newest truck engine, the Cat 3116 engine rated at 290 hp, is presented as one logical choice for ATLAS. The FMTV Engine (Caterpillar 3116) fulfills the engineering, performance, and supportability considerations defined within this study. The 3116TA Engine (Turbocharged, Aftercooled) is a logical extension of the 3114T Engine provided on the RT100. Both engines are members of the 1.1 Liter Engine Family (liters/cylinder).

As reflected in Figure 2.2-1, the FMTV engine has been tested and evaluated with respect to fording; tests were conducted on two of the three run-off FMTV vehicle configurations. Figures 2.2-2 summarizes the characteristics of this engine arrangement.

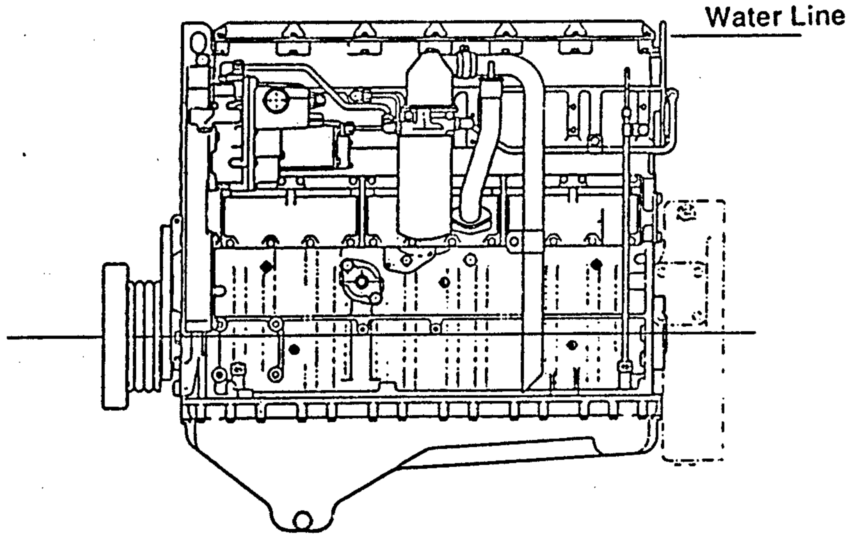


Figure 2.2-1 The FMTV Engine (Caterpillar 3116)

CATERPILLAR INC.

3116 ATAAC DIESEL TRUCK ENGINE

- 290 HP @ 2600 RPM -- 25% Torque Rise -

		SI Metric	English
General Engine Data	Power Rating and Speed	216 kW 2600 r/min	290 HP @ 2600 rpm
	Rating Type	Medium Duty	Medium Duty
	No. of Cylinders and Arrangement	6 in-line	6 in-line
	Bore and Stroke	105 x 127mm x mm	4.13 x 5in x in
	Displacement	6.6 L	403 cu in
	Combustion System	Direct Injection (DI)	Direct Injection (DI)
	Aspiration Type	ATAAC	ATAAC
	Compression Ratio	16.0 to 1	16.0 to 1
	Piston Speed	11.0 m/s	2167 ft/min
	Cycle	4	4
	Rotation -- Facing Flywheel End	CCW	CCW
	Firing Order	1-5-3-6-2-4	1-5-3-6-2-4
	Dry Unit Weight (with Flywheel)	555.1 kg	1224 lb
	Static Bending Moment @Rear Face Flywheel Housing (max.)	814.1 N-m	7200 lb-in
Air Intake System	System Restriction Limits:		
	Maximum Allowable with Clean Dry Element	3.7 kPa	15 in H2O
	Maximum Allowable with Dirty Element	6.2 kPa	25 in H2O
Air-to-Air System (Conditions of 77° F Ambient and 30 mph Ram Air)	Intake Manifold Temperature (Maximum Allowable)	43.3° C	110° F
	Charge Air Flow @ Rated	23.6 kg/min	52.0 lb/min
	Charge Air Flow @ Peak Torque	13.7 kg/min	30.2 lb/min
	Turbo Air Outlet Pressure @ Rated	280.5 kPa (Abs)	83.0 in/HG (Abs)
	Turbo Air Outlet Pressure @ Peak Torque	248.4 kPa (Abs)	73.5 in/HG (Abs)
	Maximum Turbo Inlet Temperature	36.1° C	97° F
	Turbo Air Outlet Temperature @ Rated	189° C	372° F
	Turbo Air Outlet Temperature @ Peak Torque	164 ° C	327° F
	Allowable Pressure Drop -- Turbo Outlet to Manifold Inlet	13.5 kPa	4 in Hg
Cooling System	Engine Coolant Capacity	13.2 L	14 qt
	Top Tank Temperature (Maximum Allowable)	110° C	230° F
	Top Tank Temperature (Minimum Recommended)	71.1° C	160° F
	System Capability (Min. Ambient Temp) Rated/Peak Torque +100 rpm	48.9/43.3° C	:20/110° F
	System Pressure Cap (Minimum Pressure Recommended)	68.9 kPa	10 psi
	Coolant System Regulators		
	Start to Open Temperature	82.2° C	180° F
	Fully Open Temperature	93.0° C	199° F
	Coolant Pump Flow @ 1.5m (5 ft) H20 Resistance:		
	Flow Rate @ Rated Speed	272 L/min	72 gpm
	Flow Rate @ Peak Torque Speed	148 L/min	39 gpm
	System Fill Rate (Capable of Interrupted Fill)	18.9 L/min	5 gpm
	Coolant Low Level Sensitivity:		
	Minimum Percent of Total System	9	9
	Maximum Percent of Pump Pressure Rise Loss	10	10
	Pump Cavitation Temperature (Minimum Allowable)	93.3° C	200° F
	Pump Pressure Rise Loss (Maximum Allowable)	20%	20%
	Air Venting Capability @ 35% Pump Pressure Rise Loss	0.33 L/min	0.7 pt/min
Exhaust System	System Back Pressure (Maximum Allowable)	10.0 kPa	40 in H2O

15 AUG 90

Figure 2.2-2 Caterpillar 3116 Engine Specifications Part 1

CATERPILLAR INC. 3116 ATAAC - 290 HP (continued)

		SI Metric	English
Fuel and Governor	Fuel System Type	Cat MUI	Cat MUI
	Fuel Supply Line Restriction (Maximum Allowable)	13.8 kPa	4.1 in Hg
	Fuel Return Line Restriction (Maximum Allowable)	67.5 kPa	20.0 in Hg
	Normal Fuel Pressure	365 kPa	53 psi
	System Shutoffs Offered:		
	Energized to Run -- Standard	Yes	Yes
	Energized to Shut Off -- Optional	Yes	Yes
Lube Oil System	Refill Volume with Filter Change	17 L	18 qt
	Sump Capacity:		
	Low Mark Level	13.2 L	14 qt
	High Mark Level	15.2 L	16 qt
	Maximum Allowable Oil Temperature	121.1° C	250° F
	Oil Pressure with SAE 10w30 Oil @ 99° C (210° F)		
	Normal	350.0 kPa	51 psi
	Min. @ Low Idle	103.4 kPa	15 psi
	Oil Type Recommended	API CE, CE/SG	API CE, CE/SG
Starting System (Engine with SAE 10w30 Oil)	Recommended Battery Capacity for 90-Sec Cranking (Min. CCA @-18°C (0°F))		
	Electric Start - 12 V Motor:		
	Ambient Temperature 0° C (32° F) and Above	1050 CCA	1050 CCA
	Ambient Temperature -18° C (0° F) to 0° C (32° F)	1100 CCA	1100 CCA
	Ambient Temperature Below -18° C (0° F)	1200 CCA	1200 CCA
	Electric Start - 24 V Motor:		
	Ambient Temperature 0° C (32° F) and Above	525 CCA	525 CCA
	Ambient Temperature -18° C (0° F) to 0° C (32° F)	550 CCA	550 CCA
	Ambient Temperature Below -18° C (0° F)	600 CCA	600 CCA
Performance Data @ Rated Conditions (Unless Noted)	Low Idle Speed	750 r/min	750 rpm
	High Idle Speed	2870 r/min	2870 rpm
	Altitude Capability	1525 m	5000 ft
	Starting Torque	445.7 N·m	328.7 lb-ft
	Heat Rejection to Coolant (Total @ Rated Load)	99.4 kW	5655 Btu/min
	Specific Heat Rejection @ Rated Load	0.46 kW/kW	19.5 Btu/hp-min
	Heat Rejection to Coolant (Total @ Peak Torque)	76.1 kW	4340 Btu/min
	Specific Heat Rejection @ Peak Torque	0.47 kW/kW	20.0 Btu/hp-min
	Fuel Flow to Transfer Pump (To Engine)	108.6 L/h	28.7 gph
	Fuel Flow to Return Line (From Engine)	50.8 L/h	13.4 gph

15 AUG 90

Figure 2.2-2 Caterpillar 3116 Engine Specifications Part 2

2.2.1 Basic Engine Arrangement. The FMTV engine may be provided as a commercial, basic engine arrangement in accordance with MIL-STD-1410 Methods for Selection of Industrial Engines for End Item Applications.

2.2.1.1 Engine Location. Rear mount engines are typical for RTFL applications.

2.2.1.2 Noise Engine-FMTV. The 3116 engine is quiet for a 290 HP engine operating at 2600 rpm emitting 96.4 db(A) untreated and 94.3 db(A) treated. The ATLAS engine, at 270 HP and 2400 rpm, would emit less noise than the FMTV engine.

2.2.1.3 Corrosion Resistance. The engine shall be painted with corrosion resistant primer with a topcoat of MIL-P-26168.

Various engine components experience temperatures that "burn" and effectively remove the primer and topcoat from those surfaces. Those components, i.e. turbo-charger, exhaust manifold, etc, are alloyed to provide oxidation resistance. The same alloys, (chromium, nickel, etc) that provide oxidation resistance in air provide corrosion resistance in salt water.

2.2.1.4 Waterproofing. The FMTV engine has been evaluated by the US Army with respect to fording capability. The ATLAS engine arrangement of the 3116 engine could maintain all those features.

2.2.2 Fan Disconnect. The engine fan must be disconnected before the fan is exposed to water. During a LOTS operation the fan must be disconnected with each excursion into the surf zone and reactivated upon exiting the surf zone, hence a manual fan disengagement was not considered.

The ATLAS engine arrangement provides an automatic fan disconnect to disengage the fan when a predetermined water level is encountered; alternately, the fan reengages upon exiting the surf zone.

The addition of a fan disconnect can also reduce fuel consumption. By automatically monitoring the water temperature at the radiator, the fan will be engaged only when required to provide necessary engine cooling. Fan horsepower requirements are eliminated and fuel consumption decreases.

2.2.3 Seals Crankshaft. The FMTV engine arrangement provides water fording seals on the crankshaft. Two seals are used in series to prevent contamination of the oil during fording operations.

The outboard crankshaft seal provides the double-seal needed for fording, see Figure 2.2.3-1.

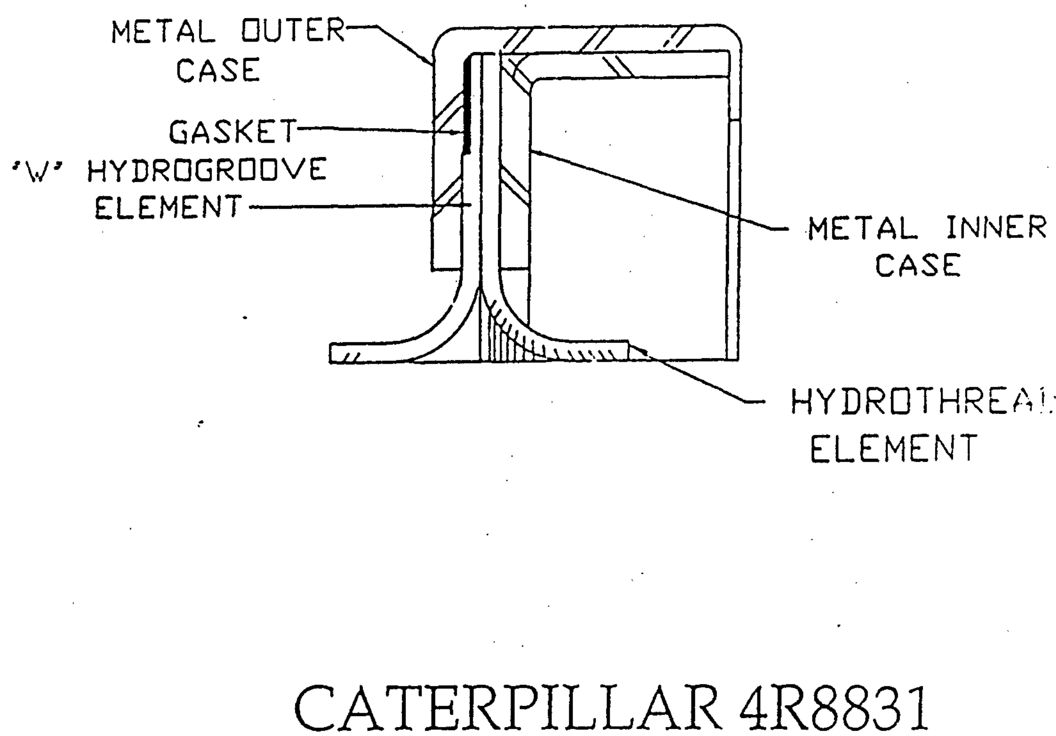


Figure 2.2.3-1 Outboard Crankshaft Seal

Pumping action provided by a hydrodynamic thread in combination with the rotation of the crankshaft excludes the water.

A second seal in-board of the engine precludes the loss of oil from the engine. As with the outboard seal, the pumping action of the hydrodynamic thread in combination with the rotation of the crankshaft stops oil loss.

2.2.4 Flywheel Housing. The flywheel housing, located below the waterline, incorporates sealed access covers and plugs.

2.2.5 Breather Group-Line. The ATLAS Breather Group-Line will be routed from the crankcase breather to a location above the splash zone. The design of the ATLAS may provide for a common breather group for submersed engine, transmission, axles, etc.

2.2.6 Heat Rejection. The 3116's low heat rejection, 20 btu/hp/minute, minimizes radiator size. Low heat rejection and small packaging results in more uniform heat distribution. "Hot" spots on the surface of the block are minimized and any thermal fatigue introduced by excursions into the surf zone are minimized.

2.3 Performance.

2.3.1 100 Hour Operation. A histogram for 100 hours of operation was developed to establish a baseline for sizing the automotive elements of ATLAS. The operational modes were defined as follows:

	% Operation
Accordion Effect (Dash Speed)	*5%*
Convoy	*25%*
Work Cycle	*60%*
Idle	*10%*

2.3.1.1 Accordion Effect. The accordion effect is defined as the lengthening and compression of a convoy. Some vehicles over a period of time will not maintain convoy speed and lengthen the convoy. Vehicles that do not maintain convoy speed must have sufficient dash speed capability to overtake the convoy within a prescribed period of time or convoy speed would be reduced.

2.3.1.1.1 Dash Speed. Operationally ATLAS is required to have a 50 mph dash speed on level (0% slope), improved surfaces. This dash speed provides ATLAS the capability to make up lost time and distance when convoying with other vehicles, 2.5 and 5 ton trucks. An unloaded ATLAS, at 270 hp, will have dash capabilites as follows:

- *2% Grade - 40 mph*
- *1 1/2% Grade - 43 mph*
- *1% Grade - 47 mph*
- *1/2% Grade - 50 mph (Max Speed)*

Figure 2.3.1.1.1-1 shows this information. Combinations of these conditions make up 5% of ATLAS's operations. This was used for calculating RAM and in sizing other powertrain components.

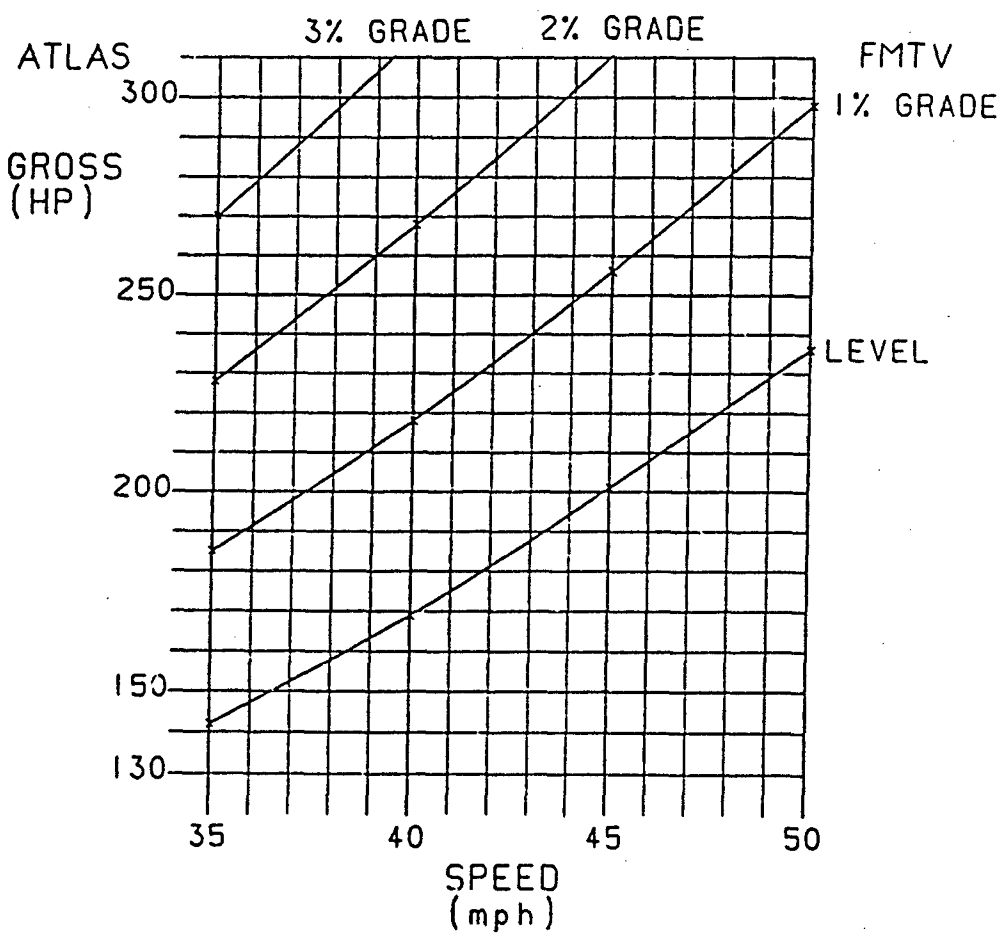


Figure 2.3.1.1.1-1 ATLAS Concept with Cat 3116 Engine

Figure 2.3.1.1.1-1 was developed based upon the following factors:

Rolling Resistance	=	*2.0% (on road)*
Frontal Area	=	*75 ft^2*
Vehicle Weight	=	*32,250 lbs.*

The effort required to overcome the rolling resistance is:

Rolling Effort	=	*Vehicle Weight x Rolling Resistance*
	=	*32,250 x 2%*
	=	*645 lbs.*

The effort required to overcome the air resistance is:

Air Effort	=	*0.0025 x mph^2 x Frontal Area*
	=	*0.0025 x mph^2 x 75*
	=	*0.1875 x mph^2 (lbs)*

The effort required to negotiate the gradient is:

Gradient Effort	=	*Vehicle Weight x Gradient (%)*
	=	*32,250 x Gradient (%) (lbs)*

The horsepower required at the wheels is:

$$HP_{Wheels} = \frac{(\text{Rolling} + \text{Air} + \text{Gradient Effort}) \times MPH}{375}$$

The net engine power is a function of the efficiency of the power train:

$$HP_{Net} = \frac{HP\ Wheels}{0.70}$$

The gross engine horsepower is the summation of the HP_{Net} and the parasitic losses*:

$$HP_{Gross} = HP_{Net} + \text{Parasitic Losses}$$
$$= HP_{Net} + 25$$

* Parasitic losses are defined as horsepower requirements of engine fan and other engine accessories.

2.3.1.2 Convoy Speed. ATLAS will be deployed in convoys with 2.5 and 5 ton trucks and similar tactical vehicles. Typical convoys will operate at speed somewhat less than the dash speed, but for extended periods of time. When convoying the ATLAS will be unladened or empty. The folowing convoy conditions were identified as typical for ATLAS and here have been used for selecting other powertrain components and calculating RAM.

8% @ — 35 mi/hr — 2% Grade — Empty
12% @ — 35 mi/hr — 1% Grade — Empty
80% @ — 35 mi/hr — 0% Grade — Empty

Figure 2.3.1.1.1-1 shows that ATLAS at 270 hp easily meets power requirements. Convoying is 25% of ATLAS's operating mission.

2.3.1.3 Work Cycle. The ATLAS work cycle is typical for RTFLs, i.e. low speed operation over undulating, unimproved surfaces, and severe grades. For purposes of this evaluation, loaded and unloaded times are equal. 60% of ATLAS's mission will be in the work cycle. The following conditions were identified as typical for ATLAS and have been used in selecting other powertrain components and RAM calculations.

60% <	*1% @ — ≥ 2 mi/hr*	*— 45% Grade —*	*1/2 Empty*	*1/2 Loaded*
	2% @ — ≥ 2 mi/hr	*— 30% Grade —*	*1/2 Empty*	*1/2 Loaded*
	5% @ — ≥ 2 mi/hr	*— 15% Grade —*	*1/2 Empty*	*1/2 Loaded*
	92% @ — ≥ 2 mi/hr	*— 0% Grade —*	*1/2 Empty*	*1/2 Loaded*

2.3.1.4 Idle. ATLAS will idle 10% of its duty cycle.

2.3.1.5 Hours to Rebuild. ATLAS engine hours before overhaul/rebuild, would be estimated at 3000 hours.

2.3.2 Capacity. Application of the 3116 Engine Arrangement does not influence the capacity of ATLAS.

2.3.3 Weight (Total and Distribution). Replacement of the 3114 engine with the 3116 engine results in an increase of 205 lbs from 1019 to 1224 lbs. The frame of the ATLAS would need to be extended to accommodate the longer engine, increasing the weight supported by the rear axle. Maturation of the design will establish the extent to which the increase in weight can be applied in lieu of additional counterweight.

2.3.4 Fuel Consumption. The ATLAS fuel consumption is strongly influenced by the gross vehicle weight, payload/load factor, duty cycle, slope, speed, efficiency of the powerplant, etc.

These data can then be reduced within a family of curves plotting torque (ft-lbs), engine power, and Brake Specific Fuel Consumption (BSFC) vs engine speed (Figure 2.3.4-1 and 2 for the FMTV Engine Arrangement). The BSFC provides a variable to compare fuel consumption of various engine sizes and duty cycles. The minimum power rating for ATLAS is 270 HP at 2400 rpm. A dual power setting of the engine may be considered to limit the maximum torque at low gears (work operations), yet provide the horsepower and rpm necessary for high speed, convoy operations.

During maturation of the ATLAS design and further consideration of operational requirements charts specific to the ATLAS engine would be developed for accurate predictions of fuel consumption and fuel tank sizing.

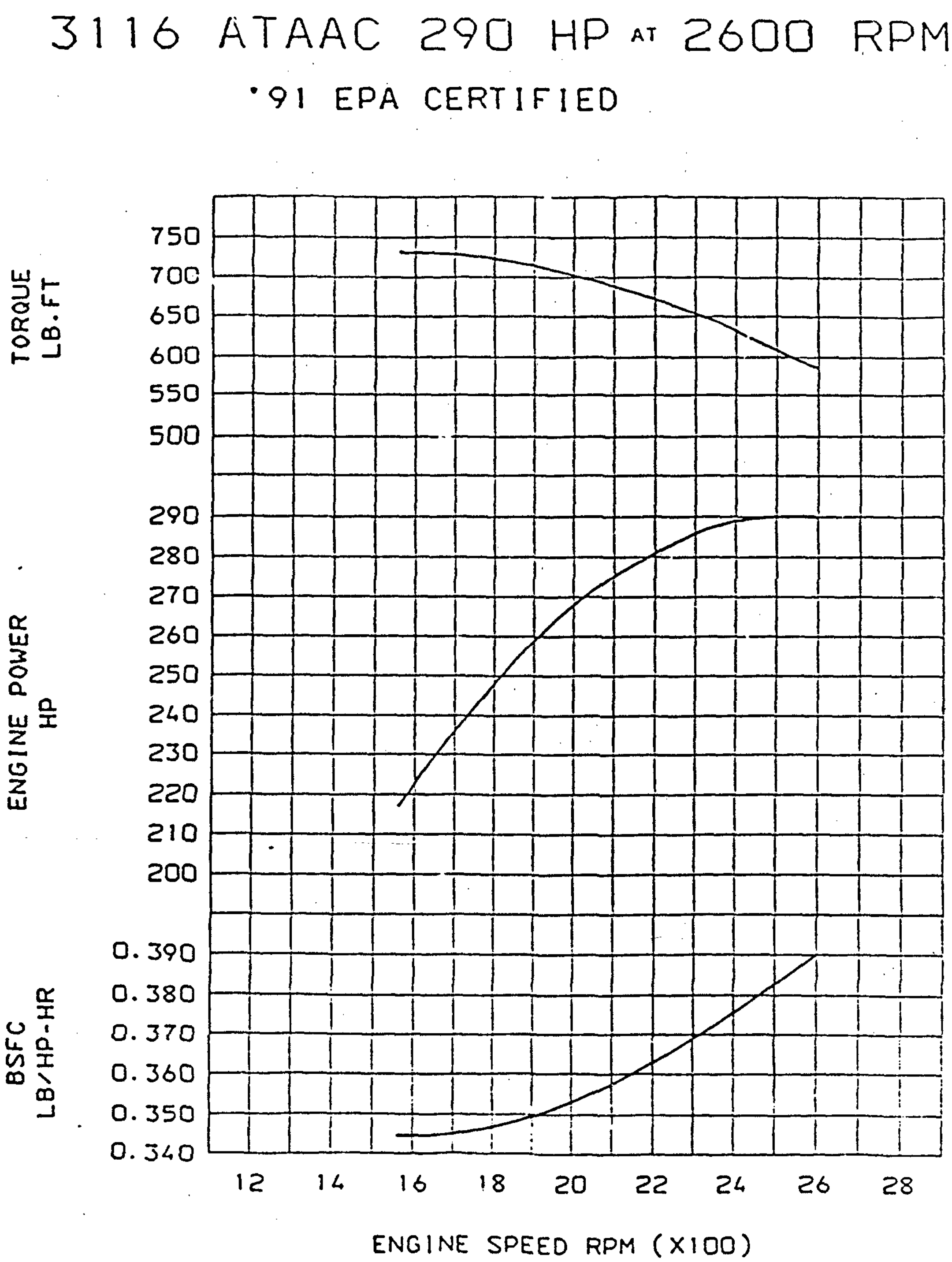


Figure 2.3.4-1 ATLAS Fuel Consumption, reference data for 3116 engine at 290 hp.

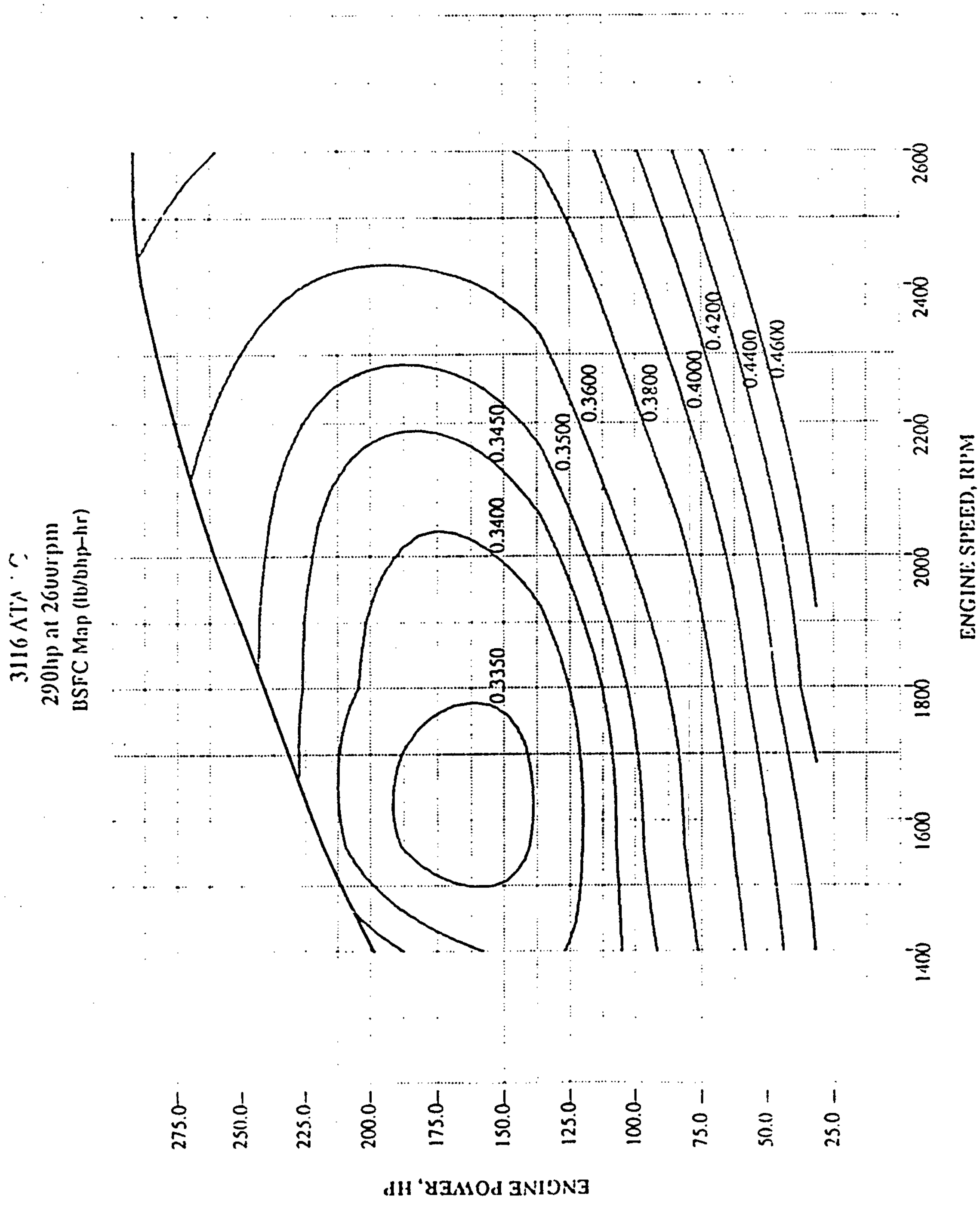


Figure 2.3.4-2 ATLAS Fuel Consumption, reference data for 3116 engine at 290 hp.

2.3.5 Vehicle Height. Vehicle height will not be influenced by the use of the 3116 engine.

2.3.6 Ground Clearance. Ground Clearance will not be affected by the use of the 3116 engine.

2.4 HFE/Safety.

Application of the 3116 engine arrangement introduces no identifiable concerns though emissions are considered with respect to safety.

2.4.1 Engine Emissions. The FMTV 3116 engine meets the 1991 EPA on-highway emissions standards.

Emissions are also a function of the ability of the engine to breath, i.e. to bring in air at low temperature and to exhaust completely leaving no gas in the combustion chamber. Close attention to these issues will assure engine performance and efficiency during excursions into the surf zone and fording during LOTS operations.

2.4.2 ATLAS Engine Configuration. The ATLAS requires a rear mount engine as opposed to a front mount engine of the FMTV. This could impact engine performance if not properly addressed during the final vehicle design phase.

2.5 Reliability.

Implementation of the modified FMTV 3116 Engine arrangement and commercially available waterproof accessories will provide a MTBF that equals or exceeds the 500 hours allocated. Upon maturation of the ATLAS design the reliability model can be refined as required.

The long term reliability (durability) of the 3116 engine has been established as a result of the FMTV evaluation at a power rating of 290 HP at 2600 rpm. The projected power requirement for ATLAS is 270 HP at 2400 rpm. This decrease in power rating translates directly to an improvement in reliability and durability.

2.6 Producibility.

Implementation of the modified FMTV 3116 engine has no detrimental effect on producibility.

Implementation of commercially available waterproof engine accessories have no detrimental effect on producibility.

2.7 Cost Impact.

ATLAS engine cost will be typical of a commercial diesel engine at the 270 hp rating. Since ATLAS performance requirements are higher than commercial RTFLs in this load capacity, engine costs will increase roughly equal to the percentage increase in engine power. The important fact is that commercial engines are available to meet ATLAS's requirements. The engine cost would increase by approximately 50%.

Implementation of commercially available engine accessories will minimize cost growth though a water-resistant accessories are typically 50% more than standard accessories whereas waterproof accessories are typically 100% more expensive than standard accessories.

Cost savings due to FMTV provisioning of the 3116TA engine, will be realized. Items changed to meet ATLAS will be the only items requiring separate provisioning. With the excellent reliability and fuel economy exhibited by the 3116 engine, substantial life cycle cost (LCC) savings will be realized. Additionally, LCC savings due to the inherent maintainability and simple, reliable design of the 3116 should be realized.

2.8 Integrated Logistic Support.

Implementation of the basic arrangement of the FMTV 3116 engine will reduce ILS impact on the ATLAS program. Provisioning costs will be minimized by FMTV provisioning of a similar engine. The excellent inherent maintainability of the 3116 has been proven by commercial application and successful maintenance by Army personnel during FMTV endurance testing and teardown for logistic demonstration. The reliability and availability of the engine are excellent as shown by commercial application and FMTV endurance testing. The engine is designed to optimize reliability, with design features as listed above.

The 3116A engine has inherently high durability due to the simplicity and sizing of engine components. The durability of the FMTV engine will be even higher in the ATLAS vehicle, due to reduced RPM and horsepower. The sizing of the engine block, to minimize hot spots, is particularly important (to minimize danger of block damage by asynchronous cooling) when operating in the surf zone.

The Army parts system, with a base minimum of 16,000 FMTV engines, will be well prepared to handle the addition of ATLAS engines. Additionally, the worldwide Caterpillar support network will be available to assist with emergency maintenance/ parts requirements as proven recently during Operation Desert Shield and Desert Storm.

Paragraph 3.0
Operator Compartment

3.1 Baseline Description.

The RT100 incorporates a standard cab arrangement with a step up, side access.

3.2 Alternative Design.

The cab will be a new design to fulfill the fording and NBC requirements of ATLAS.

3.2.1 Requirements.

3.2.1.2 NBC Warfare. ATLAS is expected to operate in a Nuclear Biological and Chemical environment.

3.2.1.3 Transport. ATLAS shall have a C130 drive on/off capability without removal of the vehicle cab.

3.2.1.4 Considerations. The fording requirement may be addressed via three approaches with the accept/reject rationale;

a) Do Nothing. Assume the cab leaks and take appropriate action inside the cab to waterproof instruments, electronics, etc. The do nothing approach was rejected as the presence of water would degrade the protection provided by the MOP IV gear in NBC environments. The water level would be above the waist of the operator.

b) Seal Standard Cab. Prevent the ingress of water 100% into the (standard) cab by sealing electrical/mechanical penetration points, windows, doors, etc. Add a bilge pump to minimize standing water. Sealing standard cab was rejected based upon the extreme difficulty in maintaining the door seals (below the waterline) over the life of ATLAS.

c) Water-Proof Cab. Develop a water-proof cab (new design). A submersible structure (bathtub) below the waterline would eliminate leaking/weepage of water through the bulkhead.

ATLAS requirements to operate in a Nuclear Biological and Chemical and environment in conjunction with the fording requirements and a transportation requirement for C130 drive on/off capability without removal of the vehicle cab necessitated the concepting of a waterproof cab.

3.2.2 Water-Proof Cab. The water-proof cab concept (Figure 3.2.2-1) necessitated that a number of concepts evolve to fulfill ATLAS requirements including:

a) Submersible Structure,
b) Superstructure/Operator Access,
c) Penetration Points, and
d) Cofferdam/Bilge Pump.

A waterproof cab precludes raising the cab from further consideration.

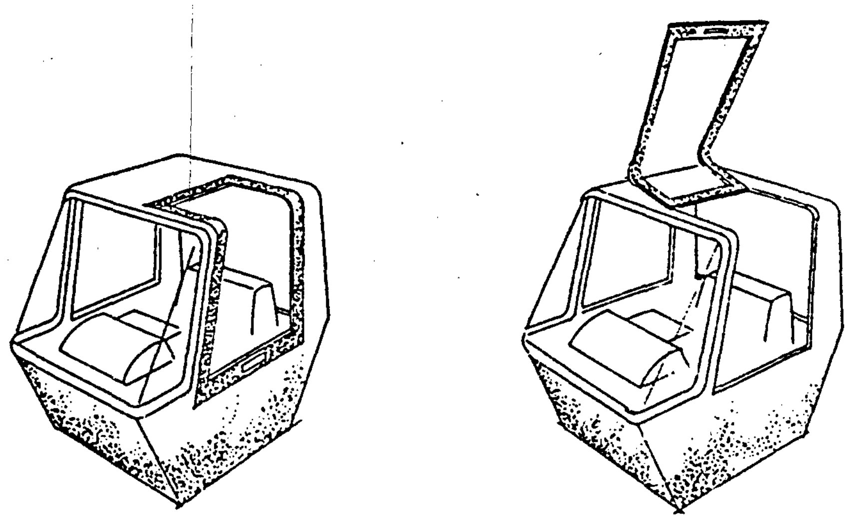


Figure 3.2.2-1 Water-proof cab with gull-wing door

The waterproof cab would be sensitive to fording requirements between the depths of 15 and 60 inches. A fording depth of 15 inches would not required a submersible structure, waterproofing of penetration points, nor consideration for a bilge pump. Fording requirements greater than 15 inches requires sealing of the penetration points and an increasing portion of the cab to be a submersible structure with a bilge pump. The height of the operator access decreases, see Figure 3.2.2.2.1-1, with an increasing fording requirement.

3.2.2.1 Submersible Structure. The submersible structure provides a welded "bathtub" structure that will be submersed below the waterline.

3.2.2.2 Superstructure/Operator Access. The superstructure above the waterline will consist of operator access, a FOPS (falling object protection structure), and the glass enclosure (including provisions for the emergency exit).

3.2.2.2.1 Operator Access. The operator will access the vehicle via a "gull-wing" door. The door will be located completely above the waterline (Figure 3.2.2.2.1-1). It provides accessibility to the operator's station by allowing the operator to step down into the operating compartment. The gull-wing door is comprised of access height, depth, and width.

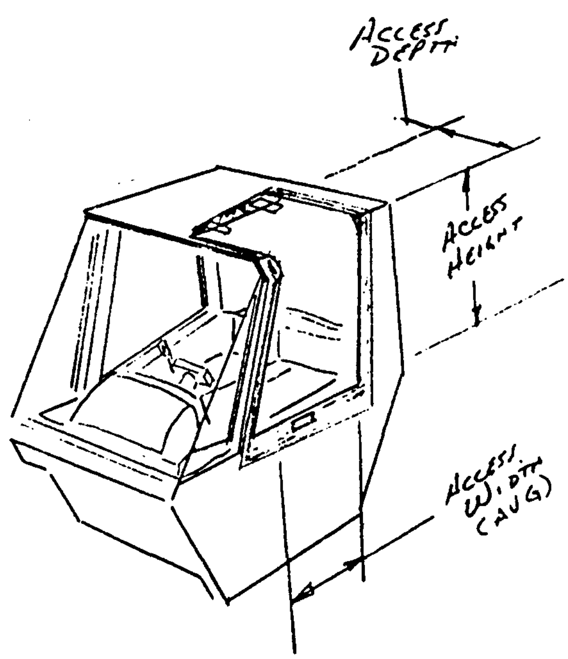


Figure 3.2.2.2.1-1 Operator Cab with gull-wing door

The door concept is a trade-off between maintaining the watertight seal of a door that would extend below the waterline and accessibility by the operator (human factors engineering/safety issues that may be addressed with maturation of the ATLAS design). Reduction of the fording requirement would, in general, improve accessibility by the operator as door height increased.

3.2.2.2.2 FOPS. The falling object protection (FOPS) will be an extension of commercial cab technology. Inclusion of the "gull wing" operator access will require an engineering assessment of the FOPS structure.

To fulfill FOPS requirements with a gull wing door the cab would require a number of structural changes. The horizontal component of the gull-wing door would require sufficient structural integrity to assume and distribute the load. This may be accomplished with a single steel plate or shroud.

The cut-out from the cab overhead would be designed to accommodate the loading from either the horizontal plate of the gull wing door or balance of the overhead structure.

3.2.2.3 Penetration Points. The submersible structure provides for waterproof penetration points below the waterline. Waterproof bulkhead connectors are available for the electrical (including coaxial for CCTV), hydraulic, pneumatic, and microclimate systems.

Mechanical penetration points would be eliminated via the application of spring-applied, hydraulic release mechanisms for the parking brake and engine acceleration.

3.2.2.4 Cofferdam/Bilge Pump. The bilge pump provides a level of redundancy that in combination with a cofferdam below the floor of the cab would exhaust any water that circumvented the submersible structure and sealed penetration points. The cofferdam would provide a drain plug that would also serve as an inspection point. The presence of water in the cofferdam would trigger a maintenance action.

3.2.3 Ventilation. Typical RTFL operations may be conducted with an open rear window and supplemental fans.

3.2.4 Glass. The development of a sealed cab with limited ventilation necessitates consideration of tinted/treated glass to minimize heat build-up in the cab (greenhouse effect) and micro-cooling power requirements.

Potential maturation of a requirement for specialized laminated glass permits consideration of bullet-proof glass providing a low-level of ballistic protection.

3.3 Performance.

Implementation of the waterproof cab will degrade ATLAS performance only to the extent that minimal weight (<200 lbs) is added to the vehicle.

3.4 HFE/Safety.

The water proof cab substantially mitigates a number of operator survivability risks associated with conducting a LOTS operation in a NBC environment. The waterproof cab provides for operator access and emergency egress above the waterline permitting the operator (in MOPP IV gear) to safely exit the vehicle during a LOTS operation. Immersion of the MOPP IV gear in water compromises the level of protection provided by that gear.

A number of HFE and safety issues must be addressed with the maturation of the ATLAS waterproof cab design and the fording depth/operational requirements.

The primary issues is safe and easy operator access and egress for other than LOTS operations. The minimum access height expected for the gull-wing door is 40 inches with an access depth approximately equal to the half the width of the cab. The access width of the door may be proportioned accordingly to facilitate operator access and egress.

The cab would provide a combination of steps, toe holds, and grab handles to permit the operator to safely and effectively enter/egress the cab.

The step would be a single rung with supporting wire rope. A toe hold would be provided as a second step to support the operator. An exterior grab handle would be provided. A second grab handle and step would be provided within the cab to support the operator as he sits down within the cab. Once seated the operator would secure the gull wing door in the retracted or closed position.

3.5 Reliability.

The waterproof cab minimizes the unreliability associated with operating a vehicle with stringent fording and NBC requirements.

3.6 Producibility.

The waterproof cab will be a new design.The primary producibility trade-off is the design of the door. Sealing a standard door would require stringent dimensional conformance to fulfill the watertight integrity requirements.

Conceptually, the gull-wing door and frame would be manufactured as a serviceable, module with minimal assembly required at the vehicle assembly operation.

3.7 Cost Impact.

The cost of the gull-wing waterproof door would be a factor of two greater than a conventional waterproof door or a factor of four greater than a standard RTFL door. The water-proof cab structure would be comparative in cost with a standard cab. The cost growth associated with a water-proof cab is defined in other sections of this study, notably 4.0 Electrical/Instrumentation and 5.0 Suspension and Steering.

3.8 Integrated Logistic Support.

Implementation of the water proof cab with a serviceable water-proof door facilitates repair-by-replacement of the module. Locating the door seals above the waterline minimizes the criticality of maintaining those seals.

Paragraph 4.0
Electrical/Instrumentation

4.1 Baseline Description.

The baseline description establishes the electrical instrument arrangement of the RT100 from which the alternative ATLAS designs evolve.

4.1.1 Electrical System and Cold Start. The 12-volt negative ground electrical system has a 100 amp-hr maintenance-free battery, a 60 amp alternator and an enclosed, positive engagement starter. An anti-restart ignition key switch prevents engaging the starter when the engine is already running. A 60 amp circuit breaker protects the alternator and fuses protect the other electrical circuits. The fuses are located under the hinged dash in the operator compartment.

The standard starting system is capable of starting the engine down to 32° F (0° C). An optional Cold Start Package provides an ether starting aid and dual CAT 100 amp-hr batteries for extra cranking capacity to start the engine below 32°F (0° C).

4.1.2 Electric-over-Hydraulic Controls. Electro-hydraulic control system eliminates mechanical linkages and hydraulic lines for increased reliability.

4.1.3 Electric Transmission Control. Electric transmission controls eliminate mechanical linkages, and internal oil passages eliminate external oil lines for increased transmission reliability.

4.1.4 Boom Controls. The RT100 implements:

a) Single Lever Control,

a) the Kruger System Mark III,

b) Auto-Height Control and

c) Auto-Reach Control

4.1.4.1 Single Level Control. Control of the boom is achieved through one 3-axis joystick. This joystick inputs a signal into the Electrical Control Unit (ECU). Upon receiving this signal, the ECU outputs a signal, the magnitude of which is relative to joystick position, to the valve for that particular function. This proportional control feature provides very precise control of the boom motions.

A thermistor is built into the main hydraulic valve-bank. It permits the system to automatically compensate for any change in solenoid resistance, due to temperature change, and provides constant response charactistics over the entire operating temperature range.

4.1.4.2 Kruger System Mark III. The Kruger System Mark III load moment device monitors the load for comparison to the load chart. At such time that the operator exceeds the safe operating limits, the system will "advise" the operator via an audible/visual alarm and/or a shut-off device to preclude the operator from increasing the load-moment. The system is environmentally sealed.

4.1.4.3 Auto Height Control. The operator has the ability to automatically maintain a constant height of the forks to horizon when telescoping out or in. The boom is positioned manually to the desired height. This distance is automatically set when Auto mode is selected by a switch on the dash. The ECU then begins computing boom length, boom angle and chassis angle from information supplied by three syncronized sensors.

Auto Height operates by simply selecting a telescope function as illustrated by the following example. As the boom moves out, the ECU is constantly updated with information from the three external sensors and drives the telescope out, and boom raise or lower valves automatically maintain the selected height.

The chassis inclinometer allows the ECU to compare actual chassis angle to the horizon. This means that even if the truck is working in rough terrain, the height of the forks remain true to horizon, not to chassis angle.

4.1.4.4 Auto Reach Control. The operator has the ability to maintain a constant distance between the center of the front axle and the front of the forks with respect to horizon when boom lowering or raising. The boom is positioned manually to the desired reach. This distance is automatically set when Auto mode is selected by a switch on the dash. The ECU then begins computing boom length, boom angle and chassis angle from information supplied by the three sensors.

The selection of boom raise or lower results in the ECU driving the chosen valve and the telescope in or out valves automatically to maintain the set distance between the front of the fork and the center of the front axle.

4.1.5 Harness-Wiring. Premium wiring harnesses are waterproof and protected from abrasion for long, reliable service.

4.2 Alternative Design.

The electrical system of the RT100 provides many of the features required by ATLAS though a number of alterations are required.

4.2.1 Requirement. Electrical requirements are derived from MIL-T-53038(ME). Maturation of the ATLAS Program will include many of these requirements.

4.2.1.1 Electrical system. The forklift electrical system would be for heavy duty, 12 volt or 24 volt service, and in accordance with SAE J539. All electric wiring would be routed so as to provide ease of maintenance and maximum protection.

4.2.1.2 Batteries. Batteries would be furnished and shall be in accordance with MS35000 Battery, Storage, Lead Acid, Waterproof, type 6TN and would be readily accessible for service. The batteries would be negative grounded in accordance with SAE J538. The battery terminals would be accessible for removal without requiring disassembly of other components.

4.2.1.3 Battery mounting. Batteries would be located so they can be cleaned, serviced, and removed without removing any component except the quick-release battery box cover if a battery box is furnished. Battery supports, holddowns, and areas around the installation which could possibly be affected by dripping or seepage of acids would be protected with a coating conforming to TT-C-494, type II. The battery would be mounted in such a manner as not to interfere with access to engine components (accessories). Battery mounting would provide for complete support over the entire base of the battery and would be in such a position that the level of the electrolyte is directly visible without removing the battery from its mounting bracket or requiring the use of tools. Battery restraining claps would be provided to hold the battery in a fixed position. The battery compartment (if furnished) would have provision for drainage and provision for gas venting at or near the top of the compartment. Cover and positioning would be protected against short circuiting. Ungrounded cable would be protected by rubber grommets or insulated passages at entry to the battery box.

4.2.1.4 Battery cable. Battery cables would be furnished which meet the requirements of SAE J1127. The voltage at the storage battery terminals and the starting motor terminals including connections would not differ more than those shown in table I of SAE J541. Positive and negative cable terminals would be identified and corrosion-resistant SAE bolts and nuts provided.

4.2.1.5 Slaving components. The truck would be equipped with a 24-volt slave receptacle conforming to MS52131 Connector, Plug, Electrical Inter-vehicular Power, Cable. The slave receptacle would permit charging of the truck batteries and slave starting of the engine from an external power source and shall also provide a power

source for charging and slaving other equipment. The slave receptacle would be installed on the exterior of the truck near the battery enclosure and would be accessible to personnel standing on the ground. A plate would be furnished adjacent to the slave receptacle which reads "24 Volts".

4.2.1.6 Circuit breaker. Each electrical circuit would be protected with a circuit breaker in accordance with SAE J553 and would have labels which describe the function served by the circuit breaker. Fuses are not acceptable.

4.2.1.7 Lights. The forklift would be provided with not less than two headlamps for forward illumination, not less than two floodlamps mounted so as to illuminate the forks and MLRS, and two floodlamps for rearward illumination. The lights would be shock mounted in elastomer ring housings and would conform to SAE J598. Headlamps would conform to SAE J1029. Front floodlamps would be adjustable a minimum of 45 degrees above and below the horizontal plane and laterally a minimum of 15 degrees right and 15 degrees left and would be capable of being adjusted by the operator from inside the operator's cab. Lights positioned in such a way as to be subject to damage would be protected by guards.

4.2.1.8 Blackout lighting. A separate wiring harness may be provided for the blackout lights. One blackout headlight conforming to MS51318 Headlight: Blackout, 24 volt, Waterproof would be mounted on the extreme left within the plan outline of the forklift at the front, positioned to provide illumination when the forks are in retracted carry position. The blackout headlight would be adjustable in accordance with SAE J598. Two blackout stoplight-taillights conforming to MS51330 Stoplight - Taillight, Vehicular - 24 Volt Blackout Tail, Blackout Stop or MS52125 Composite Light - Tail, Stop, Turn, and Marker would be mounted adjacent to the rear taillights, and would be mounted in 6-inch diameter holes or would be provided with guards. Each light would be recessed not less than 1/2-inch behind the hole or face of the guard. Two blackout marker lights conforming to MS52126 Composite Light - Front, Turn, Park and Marker would be mounted on the front, one each side of the vertical centerline, at the same level, and as far apart as practicable.

4.2.1.9 Taillights. Two taillight-stoplight assemblies in accordance with SAE J585 and SAE J586 would be installed, one on the left rear and one on the right rear of the forklift, with the lens face recessed not less than 1/2-inch back of a protecting member.

4.2.1.10 Interior lighting. The truck would be equipped with gauge lighting or indicators which are readily visible to the full range of user personnel. The gauges and instruments shall be adequately lighted for night operation and would have blue-green blackout lens with spectral emission in the 400 to 625 nanometer wavelength range.

4.2.1.11 Horn. The forklift shall be equipped with an electric, air, or air-over-electric horn. The horn button assembly and electrical wiring for the horn shall be constructed to be moisture and weather resistant to prevent entry of moisture when operated or stored outdoors under all weather conditions. The horn button may be mounted on the steering wheel or instrument panel.

4.2.1.12 Diagnostic Connector Assembly (DCA) Measurement Capability. The forklift would incorporate an easily accessible DCA in the operator's cab for interface with the simplified test equipment/internal combustion engine (STE/ICE) test equipment as specified in MIL-T-62314, Appendix B. The DCA would be in accordance with TACOM drawing No. 12258941. All requirements for DCA would be in accordance with the STE/ICE design guide for vehicle diagnostic connector assemblies, report No. CR-82-588-003. As a minimum, the DCA shall have the capabilities for measuring:

Engine RPM (average),
Engine power (RPM/SEC),
Compression unbalance,
Battery voltage,
Starter negative cable voltage drop.

A fuel shut-off method would be provided for running compression unbalance checks. Determination of test mode (either DCA or transducer kit (TK) shall be made by the contractor for the following test parameters:

Fuel Supply Pressure,	*Starter Motor Voltage,*
Fuel Return Pressure,	*Starter Current First Peak,*
Fuel Filter Pressure Drop,	*Internal Battery Resistance,*
Fuel Solenoid Voltage,	*Battery Resistance Change,*
Engine Oil Pressure,	*Alt/Gen Output Voltage,*
Engine Oil Filter Pressure Drop,	*Alt/Gen Field Voltage,*
Engine Coolant Temperature,	*Alt/Gen Neg Cable Voltage Drop,*
Starter Solenoid Voltage,	*Starter Circuit Resistance,*
Starter Current (Average),	*Transmission Oil Pressure.*

Test points which are inaccessible for measurement in the TK mode would be made in the DCA mode. A separate wiring harness would be provided for the DCA assembly and include all wiring and necessary hardware to perform required capabilities. The contractor would also provide vehicle test cards in the format identified on TACOM drawing No. 122258955 addressing both DCA and TK measurements and would incorporate the test cards into forklift technical manuals. Adaptors required for interface with the STE/ICE when measuring in the TK mode would be permanently installed on the forklift.

4.2.1.13 EMI/EMP. EMI requirements are considered to be readily obtained with current off-the shelf technology. The EMI requirements are per MIL-STD-461A, Notice 4 Methods RE05 & CE07.

4.2.1.13.1 CE07. The requirement is applicable for Air Force and Navy procurements for the following types of leads: AC and DC leads which obtain power from or provide power to other equipment or subsystems.

Conducted switching spikes of less than 50 microseconds in duration would not exceed the following, as applicable:

a) AC Leads: +/- 50% of nominal rms voltage
b) DC Leads: +50%, -150% of nominal line voltage

Conducted switching spikes equal to or greater than 50 microseconds in duration shall meet the transient requirements of MIL-STD-704. Spike duration is the time interval between the 50% amplitude point on the transient trailing edge and the 50% point of the transient trailing edge; high frequency ringing superimposed on the pulse leading edge or trailing edges should be ignored.

4.2.1.13.1 HEMP requirements necessitated that the vehicle be fully operational after 15 minutes and referenced Fig A10, A11, and Table A3 of QSTAG-244.

Normal operation occurs when the system is operating as intended in the absence of any fault or malfunction which degrades the performance beyond established requirements. It includes all system function required for the aircraft operation except during the electric starting of the propulsion engines and the battery start of the auxiliary power unit. Normal operation includes switching the utilization equipment, prime mover speed changes, synchronizing and paralleling of the power sources and operation from external power sources. Although transfer operation as defined herein is a normal function, it is treated separately in the standard because of the power interruption which may be produced. Conducted switching spikes, which are excursions of the instantaneous voltage not exceeding 50 microseconds, would be considered normal operation characteristics.

Transient. A transient is changing value of the characteristic that usually occurs as a result of normal disturbances such as electric load change and engine speed change. A transient may also occur as a result of a momentary power interruption or an abnormal disturbance such as a fault clearing.

Transients that do not exceed the steady state limits are defined as lesser transients. Transients that exceed the steady state limits but remain within the specified normal transient limits are defined as normal transients.

Transients that exceed normal transient limits as a result of abnormal disturbance and eventually return to a steady state limits are defined as abnormal transients.

Table II and Figures 10 and 11 should clarify the limitations.

4.2.2 Alternative Design - Electrical. The electrical system of the RT100 must be altered to meet the operational requirements of ATLAS. The RT100 implements a 12 volt water-resistant system that would be replaced with a 24 volt water-proof system. In addition the RT100 must fulfill additional requirements for close circuit television (CCTV), micro-cooling, and DCA/ICE.

4.2.2.1 Battery. The batteries of the RT100 may be located in a sealed structure or above the splash height permitting the use of water-resistant units. Alternately, waterproof batteries (MS3500) shall be required.

The 3116 ATAAC engine requires 600CCA @ 24V to start at -20°F.

Enclosed is a drawing (Figure 4.2.2.1-1) of projected battery position.

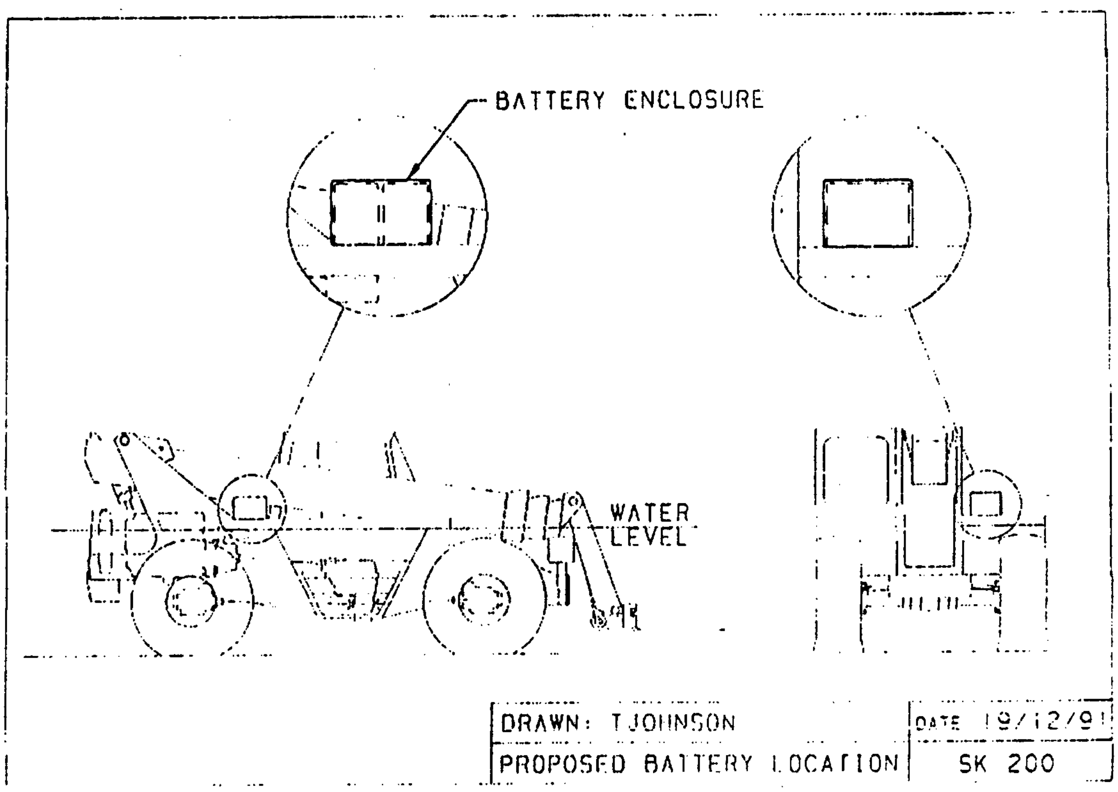


Figure 4.2.2.1-1 Battery Location

4.2.2.2 Harness Wiring. Waterproofing of the chassis wiring harnesses is central to the reliability of ATLAS.

4.2.2.2.1 Cable. SAE J1128 (special purpose, cross-linked, polyethylene cable, (SXL)) may be used on the chassis to provide a desirable abrasion resistance and meet fording requirements. Type SXL is a thermosetting material.

SAE J1128 (general purpose, thermoplastic, insulated cable (Type GPT)) may be used within watertight compartments. Type GPT cable is more flexible and workable than Type SXL for routing in tight quarters.

4.2.2.2.2 Covering. Chassis harnesses, exposed to the sea-water, will incorporate nylon braid covering providing supplemental abrasion resistance.

4.2.2.2.3 Connectors. A variety of connectors is commercially available to meet the ATLAS waterproofing requirements, including MIL-C-5015 (Caterpillar Environmental Connector (EC)), Canon Sure-Seal, Crouse-Hinds Water-Proof Connectors, and Glenair Series 22 Geo-Marine Connectors. The RT100 utilizes both the MIL-C-5015 and Canon Sure-Seal connectors.

4.2.2.2.3.1 Engineering Considerations. Space claims for bulkhead connectors may limit the applicability of Canon Sure-Seal and Crouse-Hinds Water-Proof connectors as these connectors are limited to 10 terminations. This limitation will lead to a high connector concentration between the chassis and watertight structures, particularly the cab.

MIL-C-5015 connectors, available from a number of suppliers including Canon and Deutsch, and the Glenair Series 22 Geo-Marine Connectors provide for increased number of terminations/connector to reduce connector concentrations (minimizing space claims). MIL-C-5015 connectors are considered the prime path for purposes of the fording evaluation; the Glenair and Crouse-Hinds provide viable commercially-available alternate designs to fulfill the fording requirements.

For example considering the applicability of the Deutsch HD-30 and DT connectors a number of advantages are realized including:

a) *The maximum number of terminations of an HD-30 is 31, allowing a substantial reduction of connectors in critical areas.*

b) *The HD-30 is a bulkhead connector.*

c) *Both HD-30 and DT connectors are self-locking and require no external clips (required by the Canon Sure Seal and Crouse-Hinds Water-Proof connectors).*

d) *Both HD-30 and DT connectors are environmentally sealed and meet MIL-STD-1344 (salt spray test method 1001).*

<u>4.2.2.2.3.2 HD-30 Application.</u> This connector offers a sealed bulkhead mounting applicable for use in the critical cab to chassis interface and within the cab.

The HD series of connectors is constructed of heavy duty non-magnetic metal shell and is environmentally sealed with a current rating for No. 12 and No. 16 contacts of 35 amps and 16 amps maximum, applicable within a temperature range of -55 degree C to 125 degree C.

a) The HD-30 connector may be used at the cab to chassis interface. Using the RT100 as a basis, the number of bulkhead HD-30s would be 4.

1 x 14 way (No. 16 contacts) for signal wires;
2 x 31 way (No. 16 contacts) for signal wires;
1 x 8 way (No. 12 contacts) for power wires.

Alternately the RT100 uses 15 Sure-Seal connectors to accommodate 70 signal wires and 4 power wires.

b) The HD-30 connector can be employed is the fusepanel, dashpanel, and cab junction. Using the RT100 as a basis, the number of bulkhead HD-30s would be 4.

Cab to fusepanel: 1 x 21 way (4 No. 12 contacts, 17 No. 16 contacts)
Cab to dashpanel: 1 x 14 way (No. 16 contacts)
1 x 23 way (No. 16 contacts)

Dashpanel to fusepanel: 1 x 21 way (4 No. 12 contacts, 17 No. 16 contacts).

Alternately, the RT100 uses 15 sure-seals to connect 57 signal wires and 5 power wires.

4.2.2.2.3.3 DT Series Application. The DT series connector would be most applicable in connecting the wiring harness to individual components (eg: headlights, joystick, etc.). With a size choice of 2, 3, 4, 6, 8, and 12 this connector is as versatile as the family of Sure-Seal connectors.

The DT series of connectors is constructed of a general purpose thermoplastic housings and environmentally sealed with a current rating of 13 amps for all contacts applicable within a temperature range of -55° C to 125° C.

4.2.2.2.3.4 Sure-Seal Application. Application of Sure-Seal connector may be limited by the applicability of the MIL-C-5015 connector. Alternately, expansion of the line of Sure-Seal connectors is a viable option.

4.2.2.2.3.5 Crouse-Hinds Water-Proof Application. Application of Crouse-Hinds Water-Proof connector may be limited by the applicability of the MIL-C-5015 connector. Alternately, expansion of the line of Crouse-Hinds Water-Proof connectors is not established.

4.2.2.2.3.6 Glenair Connectors. Application of Glenair Series 22 Geo-marine Connector may be limited by the applicability of the MIL-C-5015 connectors. The Glenair connectors are available with a broad range of insert arrangements (diameter and terminations) up to 24-128.

4.2.3 Alternator. The alternator (24 volt) will provide an amperage that will be determined with maturation of ATLAS. Suppression may be required to meet the EMI requirements.

The water-resistant alternator if employed must be located above the splash zone, where as a waterproof alternator may be located without regard to the water level.

FMTV utilizes a CE Neihoff (Model S-216) alternator with an output of 100 amps that may be suitable for ATLAS. The fording capability of this unit has been demonstrated.

Alternately, Prestolite Electric and Leece-Neville offer waterproof alternators that fulfill the requirements of MIL-G-46795.

4.2.4 Starter. The starter must be waterproofed.

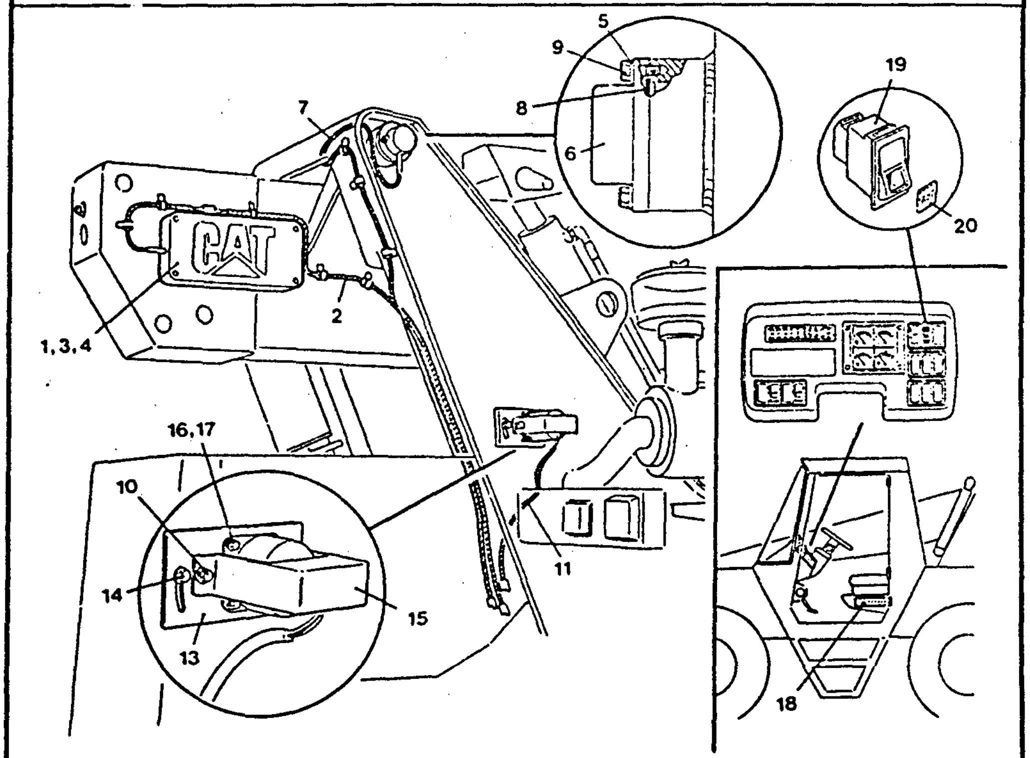
FMTV utilizes a waterproof Prestolite EO29404A electric starter suitable for ATLAS. The fording capability of this unit has been established.

4.2.5 Boom Control. ATLAS requires auto-height and auto-reach requiring minor modification to the electronic system currently used on the RT100 required to control the boom. The electrical system is comprised of:

Electronic Control Unit (ECU)
Joystick
Hydraulic Valve Manifold/Thermistor
Boom Length Sensor
Boom Angle Sensor
Load Indicator
Chassis Inclinometer/Tilt

All external sensors (Figure 4.2.5-1) are mounted above the 60 inch water line and the sensors are environmentally sealed.

ELECTRICAL EQUIPMENT (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7797	1	LENGTH SENSOR		11	6R7777	1	HARNESS AS-INCLINOMETER
	2	6R7799	1	HARNESS AS - LENGTH SENSOR		12	6R7800	1	INCLINOMETER
M	3	8T4224	3	WASHER		13	6R9065	1	INCLINOMETER MOUNTING PLATE
M	4	8T7547	3	BOLT	M	14	7X2619	1	BOLT
M	5	5P0537	2	WASHER		15	8Q2081	1	INCLINOMETER COVER AS
	6	6R7773	1	BOOM ANGLE SENSOR	M	16	8T0287	4	BOLT
	7	6R7776	1	HARNESS AS-BOOM ANGLE SENSOR	M	17	8T0328	4	WASHER
	8	6R7911	1	O RING	Y	18	6R8995	1	ELECTRONIC BOX- AUTO HEIGHT
M	9	8T4971	2	BOLT		19	6R9011	1	SWITCH
M	10	5C9553	2	BOLT		20	6R9012	1	AUTO HEIGHT PLATE

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P838836 Y
REV003

8?8836 AUTO HEIGHT/REACH GROUP

Figure 4.2.5-1 Sensor Locations

4.2.5.1 Electronic Control Unit. The ECU will require a number of modifications to accommodate the ATLAS requirements as a result of or including:

a) System Voltage. The change from a 12 volt system to a 24 volt system necessitates a modification to the power supply section of the ECU's printed circuit board.

b) Machine Geometry. The envelope dimensions, weight, center-of-gravity, etc as well as load requirements will necessitate modification of the firmware.

c) Boom Head Position. The articulated boom head would require sensors to monitor the position of the head. The head typically operates either fully up or fully down. If the head was in any intermediate position, auto height or auto reach would be disabled.

The ECU is located within the watertight cab beneath the seat of the operator. The ECU is environmentally sealed, providing redundant protection.

4.2.5.2 Joystick. The joystick is located within the watertight cab adjacent to and controlled by the right hand of the operator. The joystick is environmentally sealed, providing an additional level of redundant protection.

4.2.5.3 Hydraulic Manifold/Thermistors. The hydraulic manifold, solenoid valves, and thermistors will either be located in a watertight structure, relocated to a position above the waterline, or waterproof components will be identified.

4.2.5.4 Sensors Boom Length. The boom length sensors would be commercially available inductive proximity types. The units are environmentally sealed. The sensors would be mounted on the outer most section which would mean a cable reeling drum would be employed to interface between this section and the first section of the boom. The cable reeling drum would be located above the 5 foot water line and be environmentally sealed.

4.2.5.5 Sensors Boom Angle. The boom angle sensors would be commercially available inductive proximity types, and the units are again environmentally sealed. The sensors would, of course, be mounted on the fourth section which would mean a cable reeling drum would be employed to interface between this section and the first section of the boom. This unit would be fitted above the 5-foot water line and would be environmentally sealed.

4.2.6 Instrumentation. Instrumentation will be environmentally sealed and located within a watertight cab. Current instrumentation is implemented with a open cab arrangement of the RT100. Minimum changes to the RT100 instrument package is required to meet ATLAS requirements.

Primary machine functions are implemented via rocker switches directly in front of the operator.

The RT100's instrumentation is compatible with a 24 volt electrical system and provides for monitoring of:

a) Engine coolant temperature
b) Engine oil pressure
c) Transmission oil temperature
d) Fuel level

and an indication of:

e) Alternator no charge
f) Engine oil pressure low
g) Headlamp "High" beam
h) Crab steer engaged
i) Four wheel steer engaged
j) Turn signal left
k) Turn signal right
l) Manual mode (boom)
m) Auto mode (boom)
n) Malfunction (ECU)

To fulfill the requirement of ATLAS a number of additional features including but not restricted to:

o) Speedometer
p) Blackout Switch
r) Rear Steering Pinned (Warning Lamp)
s) Closed Circuit Television and Operating Panel
t) Fording Switch (to activate water level sensor)

4.3 Performance.

The electrical system has minimum impact of ATLAS performance with respect to vehicle capacity, weight (total and distribution), fuel consumption, speed, vehicle height, and ground clearance.

4.3.1 Weight. Replacing the 12 volt electrical system with a 24 volt system has distinct weight advantages, i.e. a reasonable sized alternator, batteries, lighter gauge wire, etc., that will not otherwise compromise vehicle performance.

4.4 HFE/Safety.

Implementation of the electrical system is central to the safe and effective operation of the ATLAS vehicie under all operational scenarios in particular with respect to the feedback provided the operator.

Electrical connectors would be keyed to provide only a one-way interface between male and female connectors.

4.5 Reliability.

The reliability of the electrical system is the single facet of ATLAS that introduces substantial, though manageable, risk. A trivial amount of water can introduce an electrical short that will disable a circuit(s) of the system. Waterproofing of the electrical system is central to the reliability of ATLAS.

In general, electronic devices will be enclosed in a waterproof structure. Electronic/ electrical devises that cannot be enclosed within a waterproof structure must be, at a minimum, water resistance and, preferably waterproof. Penetration of the waterproof structure will be via bulkhead connectors; hence, primarily wiring harnesses will be exposed to the salt water environment. These wiring harnesses shall be waterproof. The interface between the wiring bundle and the connector must be sealed to preclude the intrusion of water (weepage over time). Dummy plugs must be provided for each electrical connector that is used intermittently.

4.5.1 Connectors. A variety of connectors are commercially available to meet the ATLAS waterproofing requirements, including MIL-C-5015, Canon Sure-Seal, Crouse-Hinds Water-Proof Connectors, and Glenair Series 22 Geo-marine Connectors. The RT100 utilizes both the MIL-C-5015 and Canon Sure-Seal connectors.

4.5.1.1 MIL-C-5015 Connectors. MIL-C-5015 connectors (Figure 4 5.1.1-1) are waterproof up to 1 bar (35 feet of water). For full environmental sealing, each connector is sealed completely with a sealing grommet. A specific sealing grommet is required for each shell design. In addition, wire hole fillers are recommended but not required. Alternately the wiring bundle may be potted for environmental sealing.

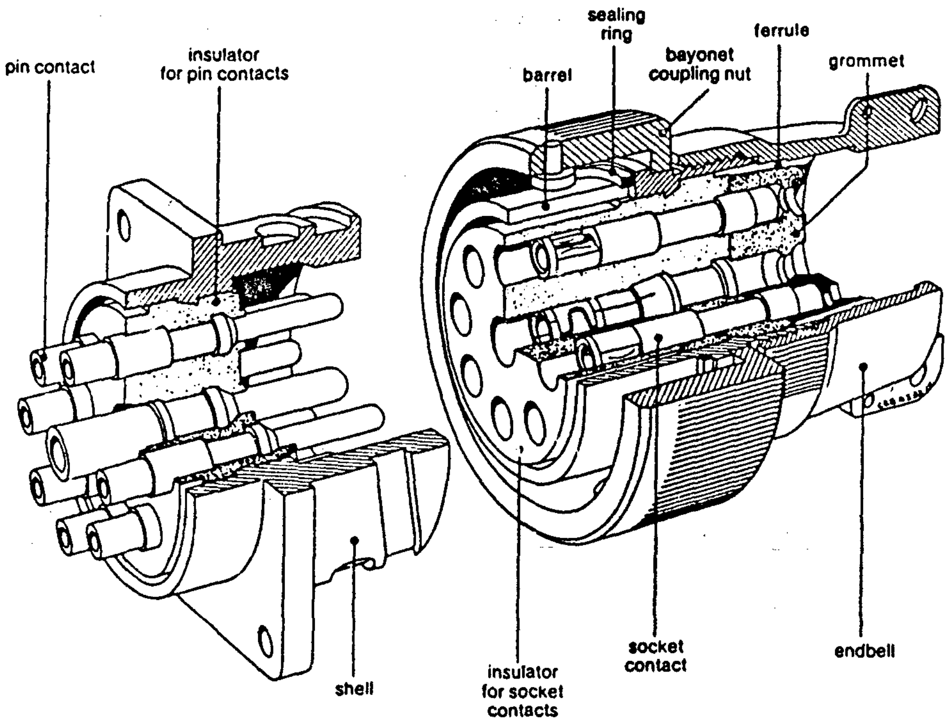


Figure 4.5.1.1-1 MIL-C-5015 Military Connector

Previous experience with MIL-C-5015 connectors has resulted in isolated problems with electrical shorts associated with weepage. The problem was resolved by removal of the sealing grommet and potting of the wiring bundle within the shell. Other connectors in the same environment performed satisfactorily.

4.5.1.2 Canon Sure-Seal Connectors. Canon Sure-Seal (Figure 4.5.1.3-1) connectors have replaced MIL-C-5015 connectors in military applications with fording requirements. Canon Sure-Seal connectors have been evaluated to depth of 3 feet immersed in a 5% salt solution to meet the minimum requirements of the FMTV program (Reference TACOM Part Number 12258940). Sure-Seal connectors provide a one-piece molded body with multiple moisture seals.

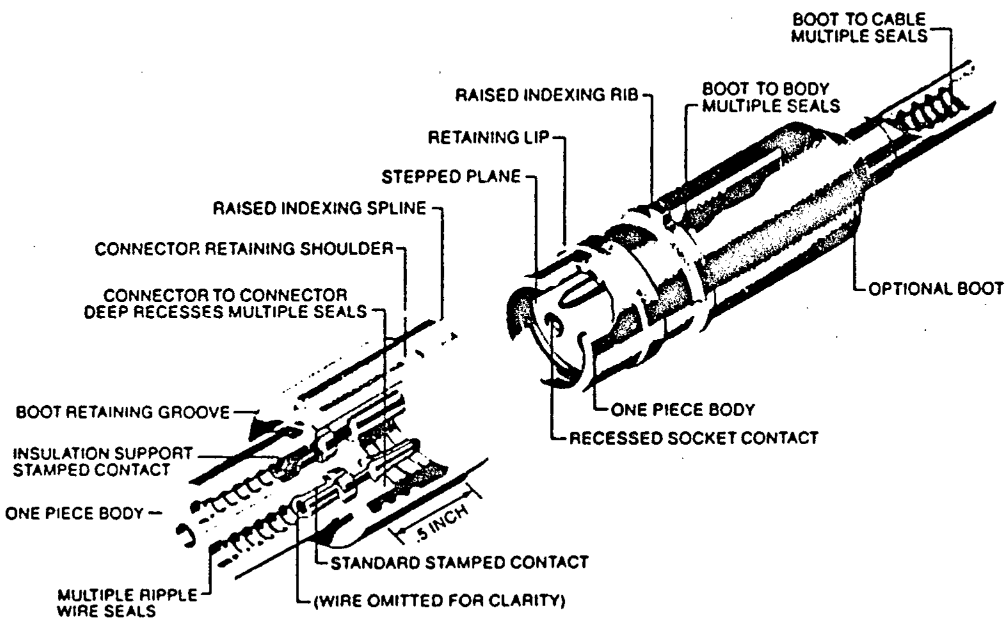


Figure 4.5.1.2-1 Canon Sure Seal Connector

Though evaluations have not been conducted at depths greater than 3 feet, no engineering limitations have been identified that would preclude consideration of these connectors for ATLAS. Though Sure-Seal connectors can withstand submersion, these connectors are not designed to be used as an underwater connector. The Crouse-Hinds Electro Water-Proof Connectors are designed for underwater applications.

<u>4.5.1.3 Crouse-Hinds Electro Water-Proof Connectors.</u> Crouse-Hinds Electro Water-Proof Connectors (Figure 4.5.1.3-1) are designed to be a waterproof connector to a depth of 20,000 psi. The connectors are transfer molded from a specially compounded neoprene formula. The connectors are vulcanized directly to the cable to provide a positive seal at all pressures up to 20,000 psi. The connectors are available with underwater connect/disconnect capability. Locking sleeves are required.

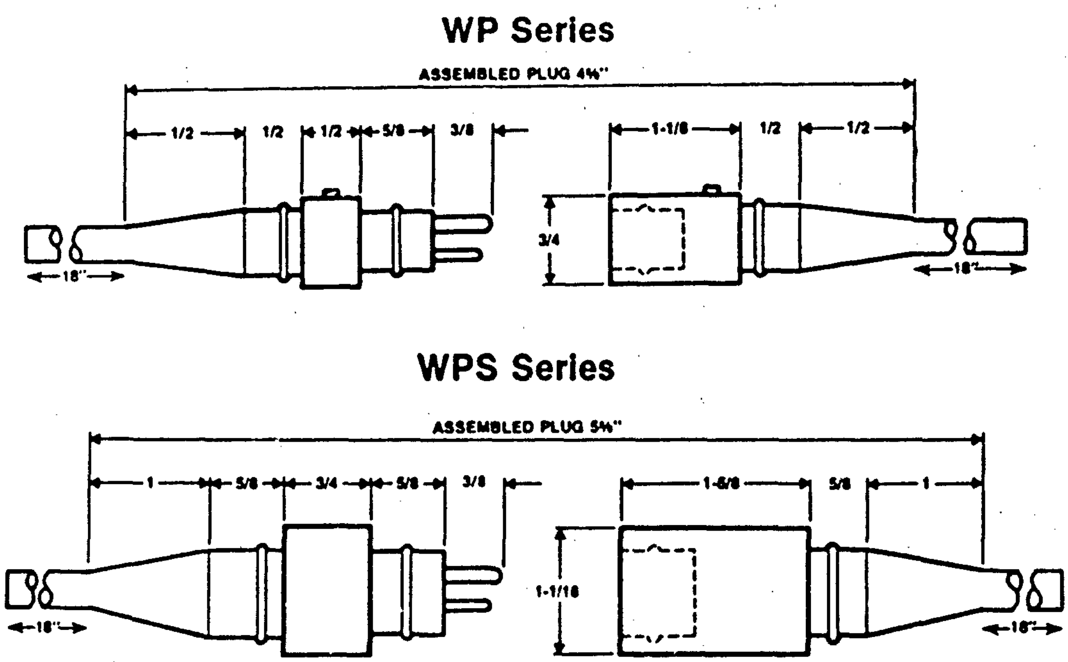


Figure 4.5.1.3-1 Crouse-Hinds Elector Water-Proof Connectors to provide positive retention.

4.5.1.4 Glenair Connectors. The Glenair Series 22 Geo-Marine Connectors (Figure 4.5.1.4) are designed as waterproof connectors to a depth of 11,500 feet (5000 psi hydrostatic sealing capability). The Glenair connectors provide the watertight integrity of the Crouse-Hinds connector with the versatility of the MIl-C-5015 Connectors.

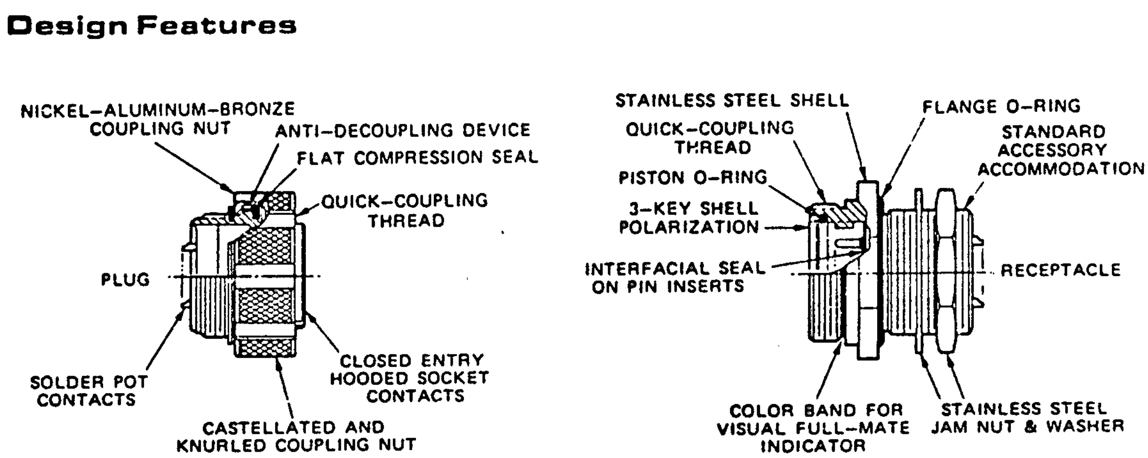


Figure 4.5.1.4 Glenair Series 20 Geo-Marine Connector

The connectors are available in a stainless steel (QQ-S-763, AISI 316L passivated per QQ-P-35) incorporating a flat compression seal and a piston O-ring (MIL-G-21569, Class 1) provides a watertight seal in conjunction with an interfacial seal for each pin contact insert. Pin and socket contacts are gold plated (per MIL-G-45204, Type II, Class 1) for maximum corrosion resistance. Molded cable-to-terminations with jackets of neoprene, polyurethane, or viton are available.

4.5.2 Electric Controls. Implementation of electric-over-hydraulic controls and electric control of the transmission are required to fulfill ATLAS reliability requirements in a salt water environment. The electric over hydraulic controls eliminate the mechanical linkages (with associated bearing surfaces and crevices) that would otherwise compromise the reliability of ATLAS.

4.6 Producibility.

The primary producibility issue is associated with the growth in the number of part numbers, procurement, and assembly costs required to meet any ATLAS waterfording requirement.

4.6.1 Harness-Wiring. Typically a wiring harness penetrates a bulkhead (structure) via a cut/drilled hole with a rubber grommet installed. Waterproofing this harness arrangement necessitates that:

1) The grommet be replace by a bulkhead connector and
2) That the single wiring harness be redesigned as two wiring harnesses (in-board/out-board).

A water-resistant, inboard wiring harness will be adequate within the waterproof structure (Note that a waterproof harness would provide an additional level of redundant protection). Two connectors would typically be required for each harness though the bulkhead connector may be hard wired.

A water-proof, outboard harness shall be required for harnesses exposed to the salt water environment. Two connectors would again be required.

4.6.2 MIL-C-5015 Connectors. To be considered waterproof up to 1 bar, each connector incorporates a sealing grommet to provide the desired full environmental sealing. A specific sealing grommet is required for each shell design. In addition, wire hole filler are recommended.

Alternately the wiring bundle may be potted for environmental sealing. Wires entering the potting cup shall be grouped, centered, and retained with a double wrap of vinyl adhesive tape before potting. The shell shall then be assembled and tightened such that the assembly cannot be loosened by hand. The shell assembly shall be filled with epoxy leaving no voids for conductive paths. A rigid epoxy potting compound such as Armstrong Products Company C-4/D, Locktite Megabond, or 3M Company Scotchweld DP-100 must be used to secure wires in the connector. Coupling nuts must be free to rotate and lock wire holes must be free of any potting materials.

4.7 Cost Impact.

The various connectors, suggested as alternatives, increase in cost as the water tight integrity of the connector increases. The estimated increase in cost per vehicle for electrical/instrument sealing is $1500. The specific time, frequency and depth of submersion will drive the connector requirements to achieve a seal with acceptable reliability.

4.7.1 Harness-Wiring. Redesign of single wiring harness as two wiring harnesses would increase the cost by a factor of two as the cost of a wiring harness is generally independent of harness length. The assembly costs may be unchanged if routing a comparatively long harness required substantial time.

The primary cost driver is associated with replacing an inexpensive grommet with a bulkhead connector. Assembly of the bulkhead connector will require more time than the grommet.

4.8 Integrated Logistic Support.

The potted MIL-C-5015 connector is more expensive to replace, but provides the positive seal necessary to insure high reliability in LOTS operations. Shorting of an electrical contact, depending on the device connected, could either reduce capability or render the system inoperable. The increase in maintainability costs, which are relatively minor, may be more than off-set by the overall increase in reliability of the electrical system.

The use of bulkhead connectors, to insure proper sealing of the cab, also would improve the maintainability of any wiring harness requiring replacement.

4.8.1 Serviceable Connectors. Only the MIL-C-5015 and Canon Sure-Seal connectors would be serviceable. The potted MIL-C-5015, Crouse-Hinds, and Glenair connector would be considered repair-by-replacement.

Paragraph 5.0
Suspension And Steering

5.1 Baseline Description.

The RT100 provides 3 steering modes and hydraulic steering. The vehicle suspension is provided by a combination of tires and a center pivot axle (walking beam). RTFLs normally travel on road up to 20 mph and have no additional elastic suspension.

5.1.1 Frame Leveling. The front axle is trunnion mounted to the frame and controlled by a single hydraulic cylinder to provide 12 degrees of frame tilt to either side (24 degrees total). This allows the chassis to be leveled on uneven terrain for greater lateral stability during high lifts. The frame should always be leveled before the boom is raised, but the frame should not be tilted once the boom has been raised.

The rear axle is also trunnion mounted to the frame, but it is free to oscillate 12 degrees to either side (24 degrees total). This improves traction and stability by helping to keep all four tires in contact with the ground on uneven terrain.

5.1.2 Steering. Both axles are steerable to provide three steering modes; 4-wheel counter steer, 4-wheel crab steer and 2-wheel front steer. These steering modes give the RTFL excellent maneuverability.

A three-position switch on the dash allows the operator to easily select the desired steering mode. The machine should be brought to a complete stop and the wheels aligned parallel to the chassis before changing steering modes. Indicator lights on the dash show when the circle or crab steer modes have been selected. If neither indicator light is illuminated, it means the machine is in the two-wheel steer mode.

5.1.2.1 Counter Steer. In the counter steer or circle steering mode, the front and rear tires steer in opposite directions. Circle steering is used most frequently because it provides the tightest turning radius. Circle steer also enhances traction because the rear tires track in the ruts of the front tires.

5.1.2.2 Crab Steer. In the crab steering mode, all of the tires steer in the same direction. This causes the machine to move sideways as it goes forward or backwards, while still pointing straight ahead. Crab steering is useful for "sideshifting" the machine or when working close to a wall.

5.1.2.3 Two-wheel Steer. In the two-wheel steering mode or Ackerman steer, only the front tires steer, like an automobile. This mode is normally used only for driving the machine at higher speeds.

5.1.3 Power Steering. The power steering system is fully hydrostatic. Each axle has a single steer cylinder located above the axle for maximum protection. Double-acting cylinders provide synchronized movement, with equal effort and steering in both directions. Double-acting cylinders also allow a simplified linkage with just an adjustable tie rod on each end connecting the cylinder rods to the spindles.

Hydraulics for the power steering are supplied from the main hydraulic system through a priority valve that supplies flow based on demand. The steering gear has a hydraulic control valve and a metering section that permit manual steering in the event of an engine shutdown or a hydraulic system malfunction.

5.2 Alternative Design.

ATLAS on-road speed requirements necessitate the most substantial alterations to a commercial RTFL, specifically;

a) Elastic suspension to accommodate 50 mph,
b) Provide a means of locking out the suspension mode when the vehicle is used for boom motions, and
c) Maintain a level frame capability.

Table 5.2 provide a synopsis of suspension elements with respect to various characteristics. A hydro-pneumatic suspension system with hydraulic cylinders and nitrogen over oil accumulators exhibits characteristics necessary to meet ATLAS speed requirements.

		COIL SPRING	TORSION BAR	LEAF SPRING	ELASTOMER SPRING	AIR SPRINGS	GAS/OIL ACCUMULATOR	GAS/OIL STRUT
(1.)	SIZE	large xxxxxxxxx	large xxxxxxxxx	medium	medium	medium	medium	large xxxxxxxxx
	WEIGHT	heavy xxxxxxxxx	medium	heavy xxxxxxxxx	light	light	medium	medium
	STROKE	good	good	medium	poor xxxxxxxxx	poor xxxxxxxxx	good	good
	SPRING RATE	good	good	good	stiff xxxxxxxxx	good	good	good
(2)	BUILT IN DAMPING	none xxxxxxxxx	none xxxxxxxxx	low xxxxxxxxx	medium	none xxxxxxxxx	good	good
(2)	BUILT IN LEVELING	no xxxxxxxxx	no xxxxxxxxx	no xxxxxxxxx	no xxxxxxxxx	minimal xxxxxxxxx	yes	yes
(3)	ACTIVE CONTROL	no xxxxxxxxx	no xxxxxxxxx	no xxxxxxxxx	no xxxxxxxxx	no xxxxxxxxx	yes	yes
(4)	SUPPORT SYSTEMS	no	no	no	no	air xxxxxxxxx	no	no
(5)	ADAPTIVE RATES	no xxxxxxxxx	no xxxxxxxxx	yes	yes	yes	yes	yes
(6)	ABLE TO BE TUNED	no xxxxxxxxx	no xxxxxxxxx	no xxxxxxxxx	no xxxxxxxxx	minimal xxxxxxxxx	yes	yes
	INITIAL COST	high xxxxxxxxx	high xxxxxxxxx	high xxxxxxxxx	medium	medium	medium	high xxxxxxxxx
	COMPLEXITY	low	low	low	low	low	medium xxxxxxxxx	high
	MAINTENANCE	low	low	low	low	low	medium	medium

NOTES:
1. Undesireable features are indicated by xxxxxxxxx
2. Any "built in" capability that is not present requires an additional mechanism (e.g. shock absorbers)
3. Active control indicates ability to be used with a power source and controller to actively reduce the chassis motion induced when manipulating the load.
4. Support system indicates any system required in addition to typical variable reach fork lift systems.
5. Adaptive rate indicates the inherent ability to maintain a constant natural frequency, regardless of supported weight.
6. Ability to be tuned indicates easily varied spring and damping rates to best match machine configuration and operating conditions.

Table 5.2 Suspension Elements Evaluation

5.2.1 Requirements.

5.2.1.1 Periodic Motion. The elastic suspension is required to dampen the periodic motion yet provide compliance for roading. Periodicity is related to static deflection by:

$$t = 2\,(3.1416)\,(d/g)^{1/2}$$

where: t= time to complete one oscillation in seconds
d= static deflection in feet
g= 32 ft/sec²

cr rewritten $p = (35230/d)^{1/2}$

The front axle is estimated to have a periodicity of 100 cycles/min with a deflection of 3.4 inches whereas the rear axle is estimated to have a periodicity of 80 cycles/min with a deflection of 2.18 inches.

5.2.1.2 Curb-Clearance Circle. The curb clearance circle as defined in SAE J695 shall be 34.5 feet, maximum.

5.2.2 Suspension-Travel. An elastic suspension on the front and rear axles is required to accommodate the on-road travel speed of 50 mph. Unsuspended RTFLs would experience severe pitch and bounce at speeds above 25 mph, and may cause the operator to lose control of the vehicle. This bounce and pitch motion is a result of out-of-round/ unbalanced tires, road roughness, and low damping of the tires.

Hydro-pneumatic (hydraulic/accumulator) and leaf spring were defined as prime paths early because each minimized space claims with respect to vehicle height. Secondly, hydro-pneumatic springs could also function to level frame.

The hydro-pneumatic suspension provides a hermetically-sealed quantity of gas that is compressed by hydraulic oil according to the applied load. This suspension element will assume the role of a shock absorber by throttling the valves in the oil chamber. The hydro-pneumatic suspension provides the design latitude to tailor the spring rate and dampening characteristics of the element. The primary factors that influence these characteristics include accumulator volume, displaced volume of cylinder (area x stroke), and pressure (precharge, nominal, and maximum).

Leaf springs provide one or more laminations and can assume axle and wheel control functions. Primary factors that influence spring characteristics (per SAE J788 Manual on Design and Application of Leaf Springs) include active length of the spring, number, width and thickness of leaves, deflection, stress, etc.

5.2.2.1 Suspension-Front Axle. Four links (tie rods) will pin and locate the axle with respect to the chassis frame (per Figure 5.2.2.1-1). Three of the four links act as torque reaction members whereas the remaining link locates the axle in the transverse direction.

FRONT SUSPENSION

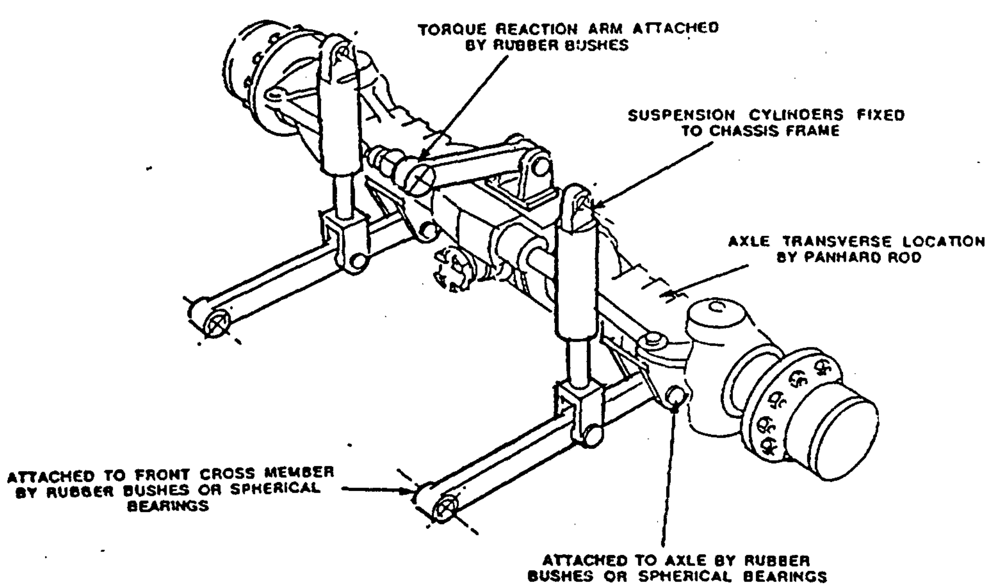


Figure 5.2.2.1-1 Front Axle Suspension

Each link is fitted with rubber bushings or spherical bearings to accommodate required motion.

The chassis frame will be supported on the axle by two hydraulic cylinders (which also provide for frame leveling).

Referring to the hydraulic circuit Figure 5.2.2.1-2, the hydraulic cylinders are plumbed to nitrogen gas accumulators to provide an elastic spring. Each hydraulic suspension cylinder will be provided with an independent accumulator.

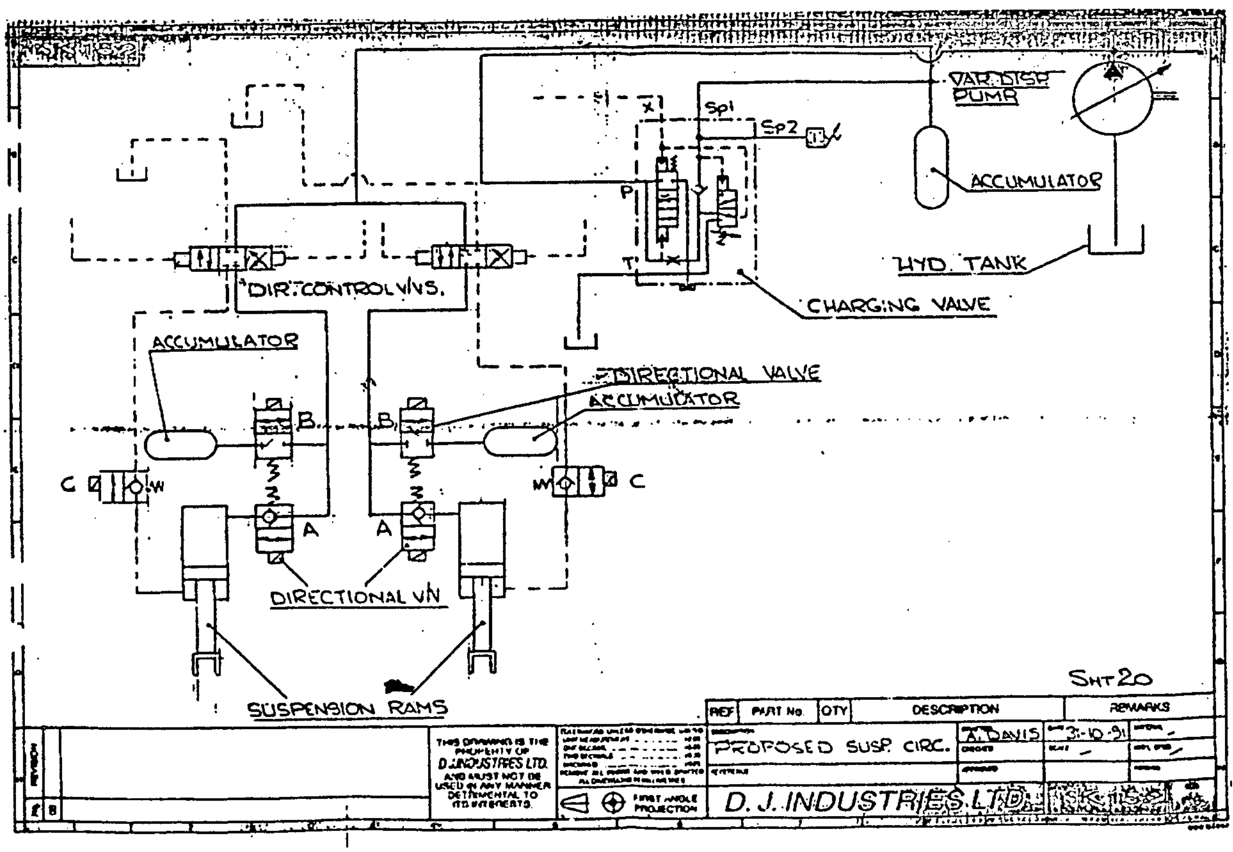


Figure 5.2.2.1-2 Hydraulic Circuit

To ensure a fast responding system, the hydraulic pump will supply a charge accumulator via a charging valve.

The oil is then directed into independent control valves for each suspension cylinder.

These control valves could be either manual, pneumatic, electric or hydraulically pilot controlled to supply oil to the system.

1. With valve "A" energized as shown on diagram, the suspension mode is locked out.

2. With valve "A" and "B" energized, the suspension is in the highway mode.

3. Valve "C" provides roll stiffness by ensuring oil on the annular side of the suspension cylinder during highway mode.

4. To level frame, operate directional control valve to provide oil supply.

5.2.2.1.1 Suspension-Front Axle (Alternate Design). Alternatively, a simpler mechanical front suspension per Figure 5.2.2.1.1-1 may be considered to replace the hydro-pneumatic suspension with leaf springs. Hydraulic cylinders are still required for frame level and locking out the leaf springs during RTFL operations.

The axle is mounted on leaf springs which are attached to a frame which can pivot relative to the chassis frame.

The springs are locked out in boom motion mode either mechanically or hydraulically. If dampers are required, these will dampen, bump stop, and lock out the springs.

One or two rams are attached to the pivoting frame and chassis frame to lock in high speed mode or frame level in boom motion mode.

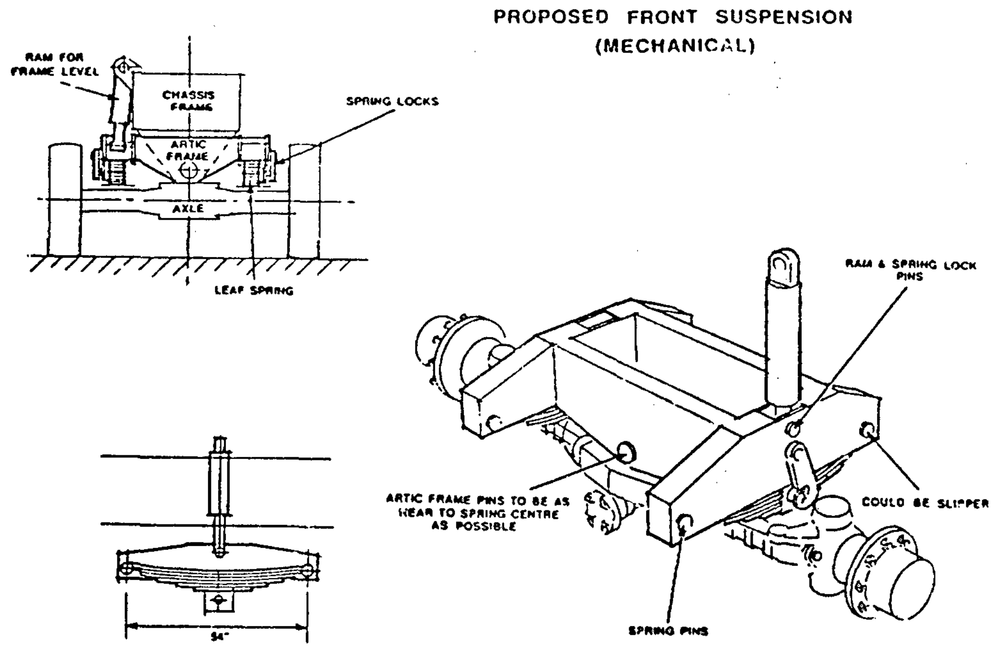


Figure 5.2.2.1.1-1 Alternate Design Front Axle Suspension

5.2.2.2 Suspension-Rear Axle. Figure 5.2.2.2-1 shows the rear axle suspension system. It is relatively simple because its worst case loading is during the travel mode.

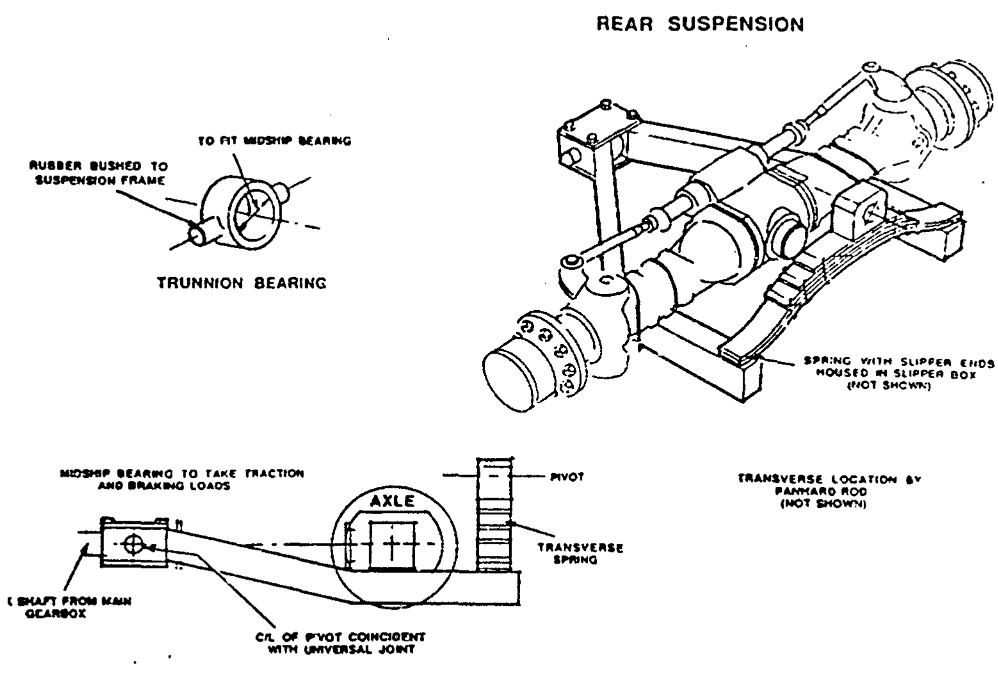


Figure 5.2.2.2-1 Rear Axle Suspension

The axle would be attached to the chassis by means of an A-frame which would take the traction and braking forces.

At the rear of the A-frame, a transverse spring is mounted which would be also mounted to a pivot under the chassis to provide 7.5 degree lateral movement.

5.2.2.2.2.1 Suspension-Rear Axle Alternate Design. The rear suspension could be either transverse spring or two rear springs similar to the front axle without the pivot frame.

5.2.3 Suspension-Working. As described in paragraph 5.2.2, in the working mode the elastic suspension of the front axle would be locked out to provide the stiff platform required for lifting operations.

5.2.4 Steering-Travel. ATLAS requirements for high-speed, on-road travel necessitates the addition of a mechanical, front wheel (Ackerman) steer and locking the rear wheels (rear steering) parallel to the centerline of the vehicle.

5.2.4.1 Mechanical Steering. The operator will steer the vehicle with the same steering wheel used for off-road steering. To transition from off-road to on-road travel (4x2 Mode) the operator would align the wheels parallel to the vehicle in any of the three steering modes. With the wheels straight the operator, would toggle a switch on the dash to lock out the rear (steering) wheels.

The mechanical system is comprised of a bevel box, steering box with an integral hydraulic cylinder (power assist), universal joint, and a steering rod pinned to the existing steering cylinder on the axle (Figure 5.2.4.1-1)

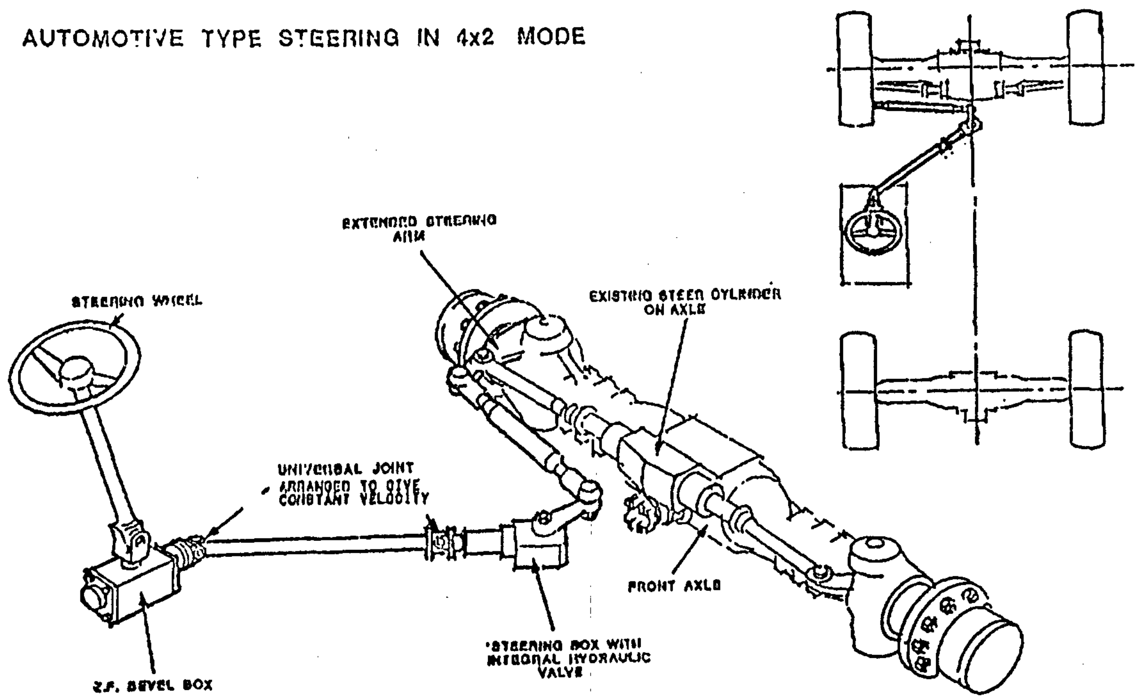


Figure 5.2.4.1-1 Mechanical Steering

5.2.4.2 Rear Wheel Lockout. Rear wheel lockout is necessary to operate ATLAS at the high speeds. The operator will toggle a switch to lock the rear steering. Alternately an automatic alignment feature may be considered (paragraph 5.2.4.1.1)

5.2.4.2.1 Automatic Alignment. An automatic rear steering alignment (Figure 5.2.4.2.1-1) could be incorporated by mechanically pinning a bar (which is linked by the steering rod) to the axle.

The toggle switch on the dash would be toggled to the LOCK position in any one of the three steering modes. The toggle switch would deactivate a spring applied, hydraulic-release solenoid valve and ride on top of a bar. Power would remain in the rear axle steering system until the pin re-extended. At that time the pin would lock the steering rod bar and axle (removing the rear steering) and switch the unlock sensor off.

Automatic alignment would provide a number of advantages including;

a) Visual indication of both the locked and unlocked conditions,

b) Rear steering would be disabled unless unlocked, and

c) Override capability to release a jammed pin by momentarily applying power to the rear steering to "joggle" the pin free.

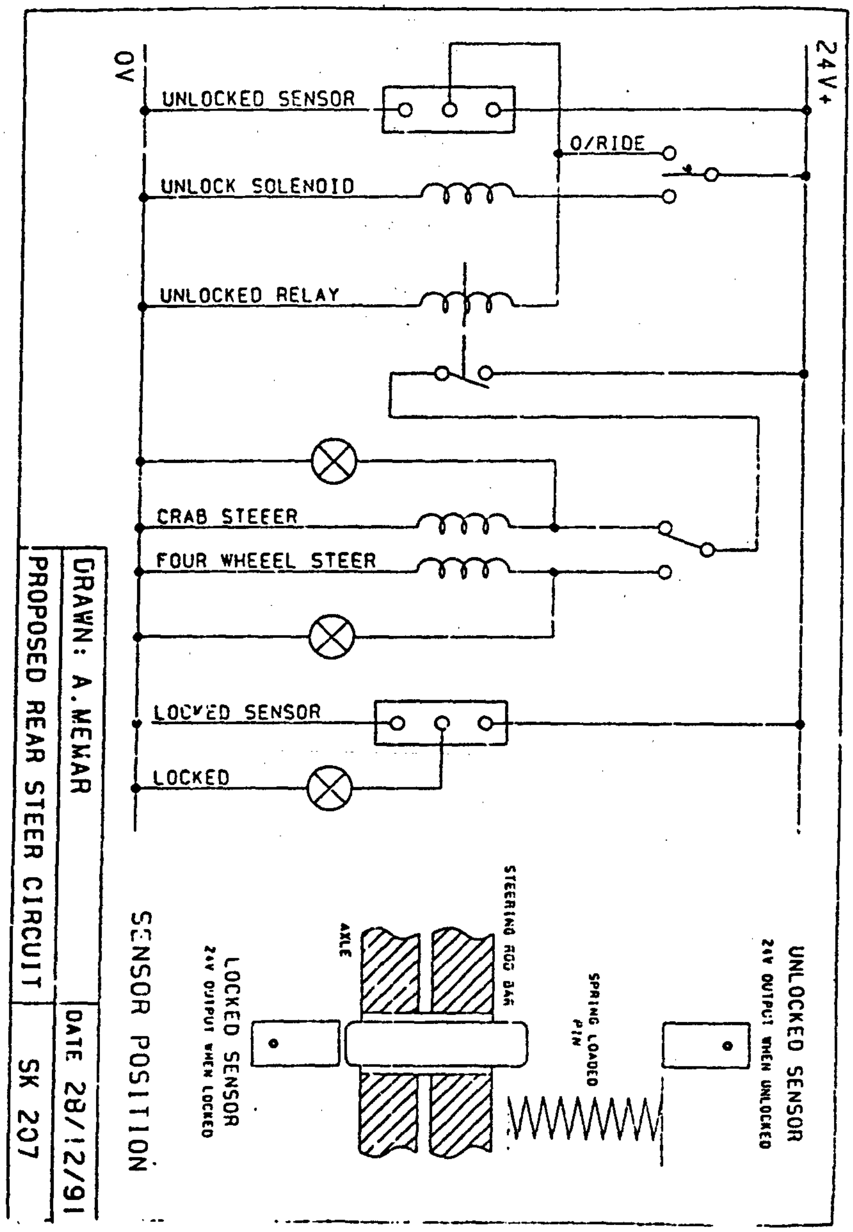


Figure 5.2.4.2 1-1 Rear Steering Circuit

5.2.5 Steering-Working. Three-steering modes, Ackerman, circle, and crab steer will be available on ATLAS and controlled from the operator dash via a switch by the operator.

5.2.5.1 Ackerman Steer. The curb-to-curb turning radius for the Ackerman steer is sensitive to tire size and lock angles per:

Tire Size	*Turning Circle*	*Reduced Lock Angle*	*Figure*
20.5Rx25	*52'0"*	*No*	*5.2.5.1-1*
20.5Rx25	*63'0"*	*Yes*	*5.2.5.1-2*
17.5Rx25	*35'6"*	*No*	*5.2.5.1-3*
17.5Rx25	*51'6"*	*Yes*	*5.2.5.1-4*

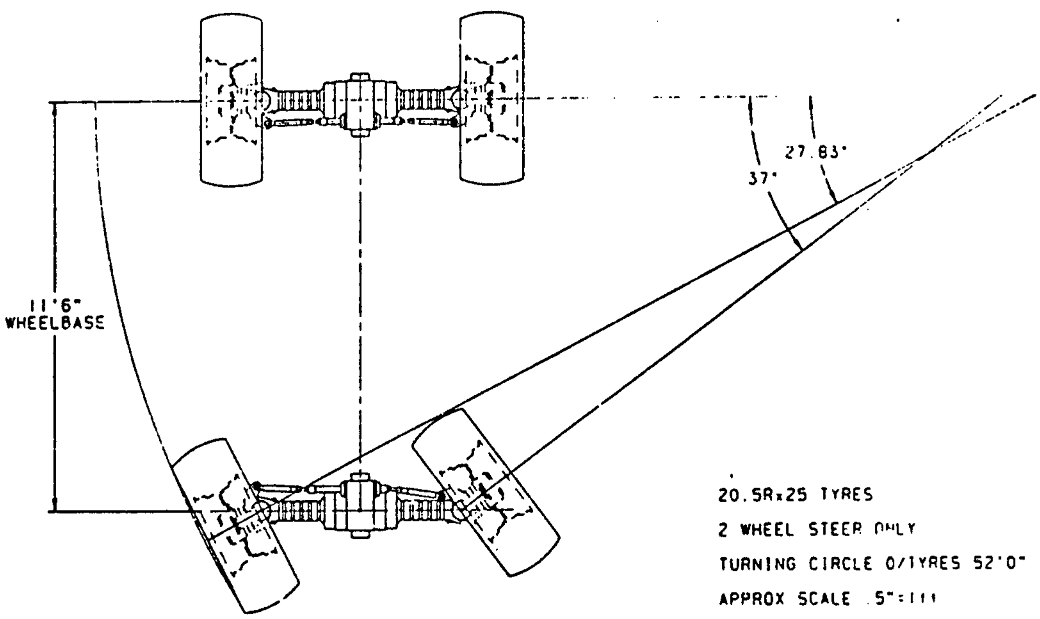


Figure 5.2.5.1-1

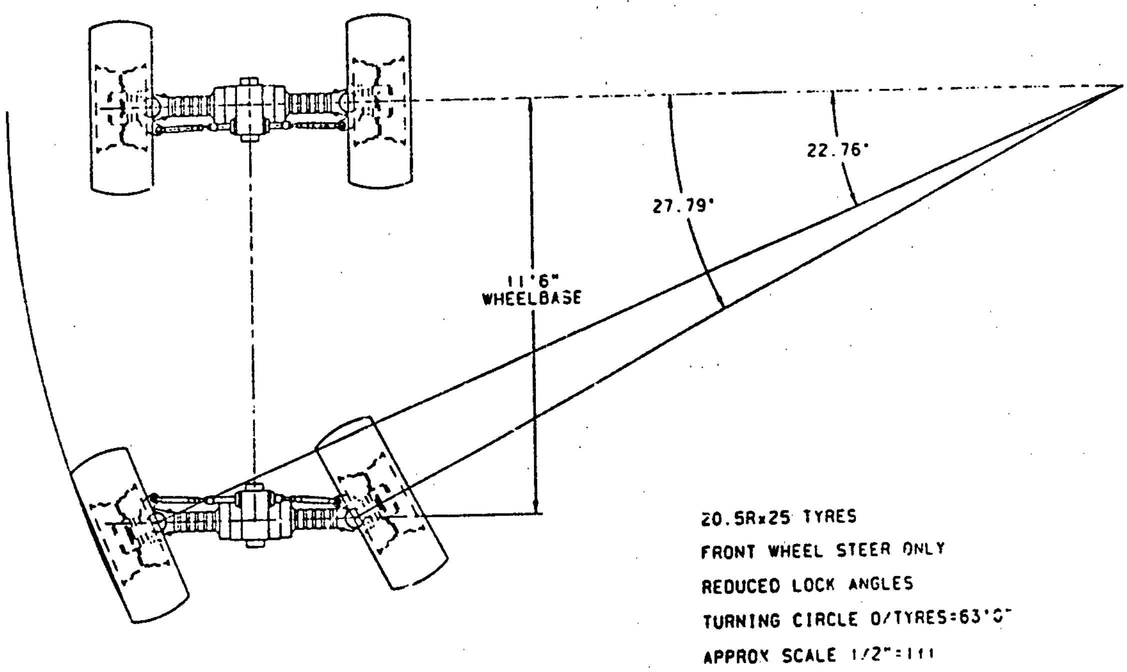


Figure 5.2.5.1-2

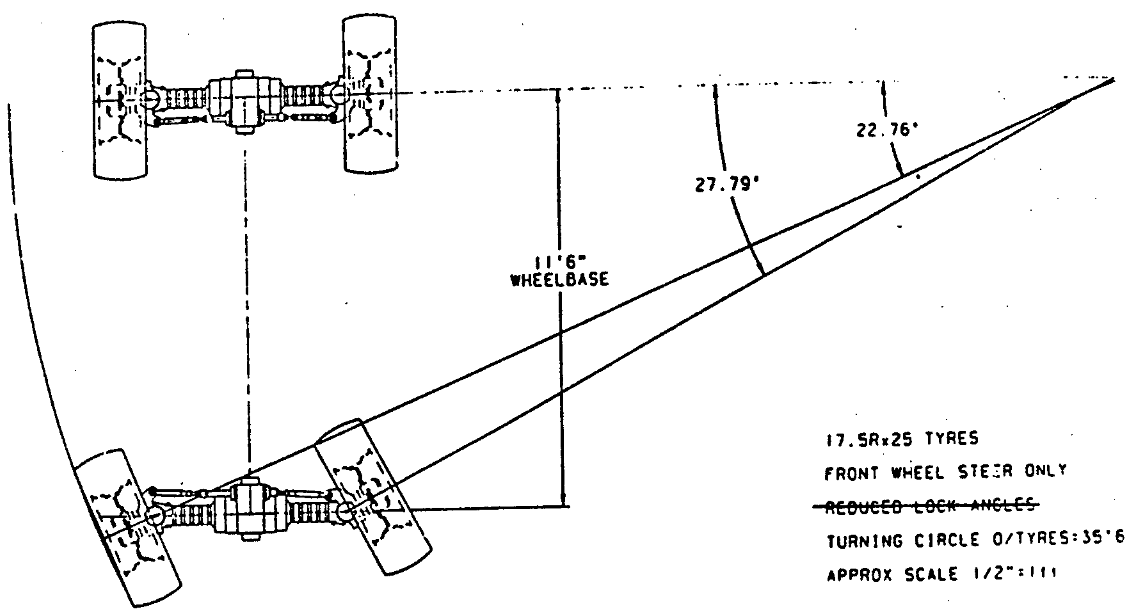


Figure 5.2.5.1-3

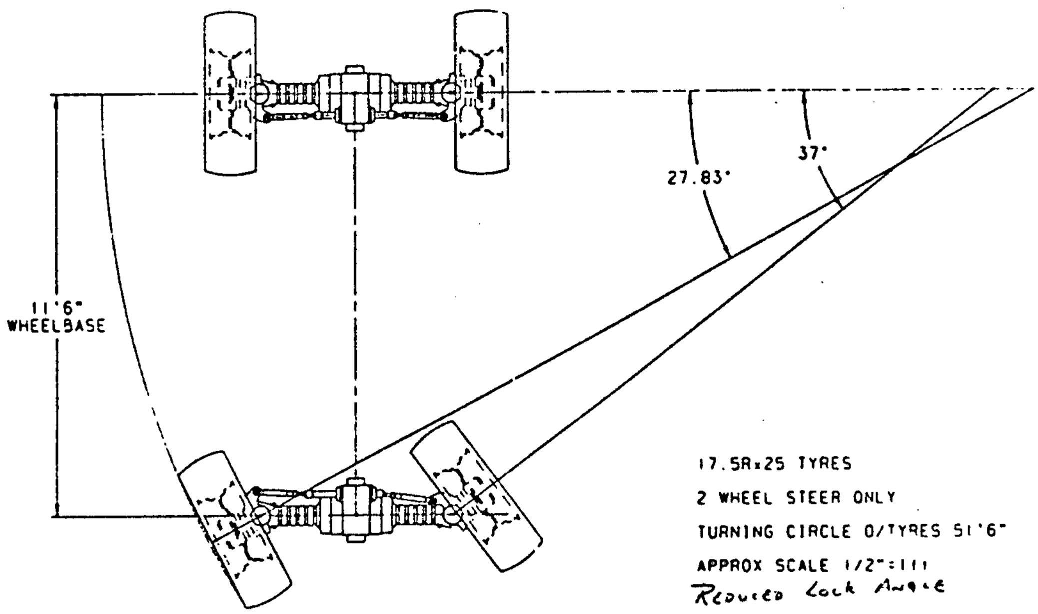


Figure 5.2.5.1-4

5.2.5.2 Counter Steer. The curb-to-curb turning radius for the counter steer is sensitive to tire size and lock angles per:

Tire Size	*Turning Circle*	*Reduced Lock Angle*	*Figure*
20.5Rx25	*31'0"*	*No*	*5.2.5.2-1*
20.5Rx25	*36'0"*	*Yes*	*5.2.5.2-2*
17.5Rx25	*30'6"*	*No*	*5.2.5.2-3*
17.5Rx25	*35'6"*	*Yes*	*5.2.5.3-4*

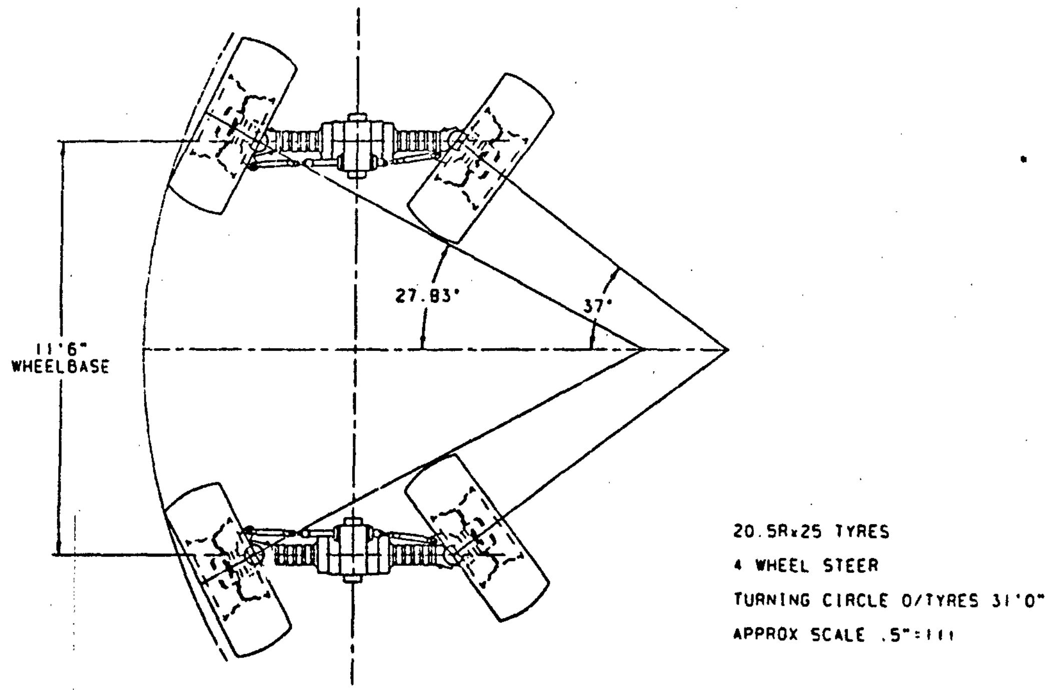


Figure 5.2.5.2-1

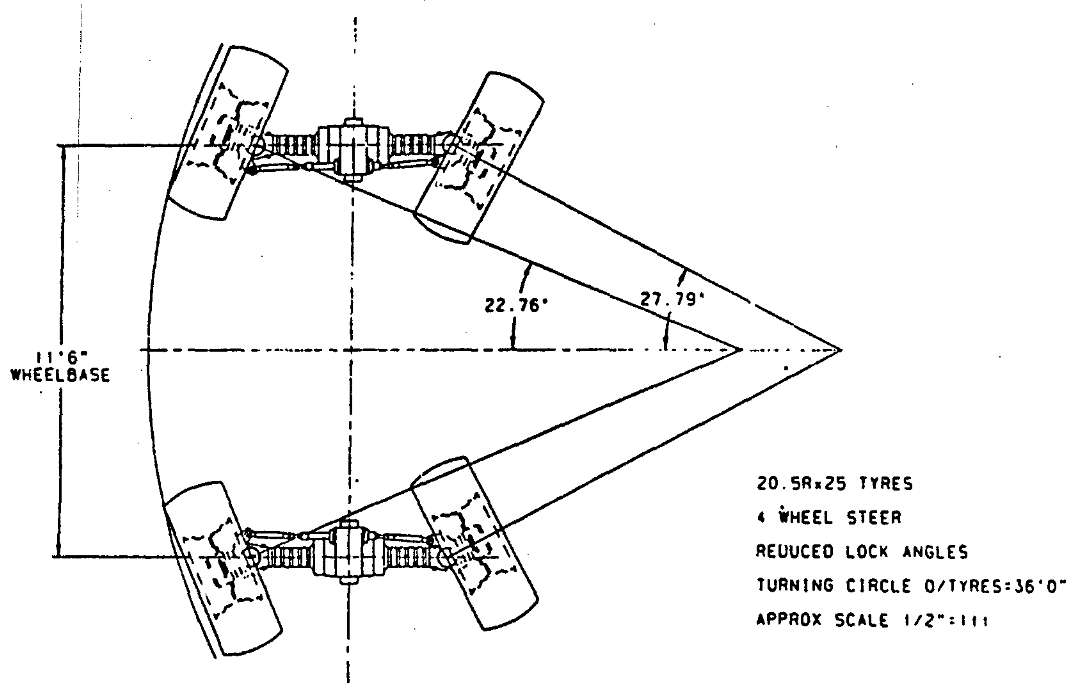


Figure 5.2.5.2-2

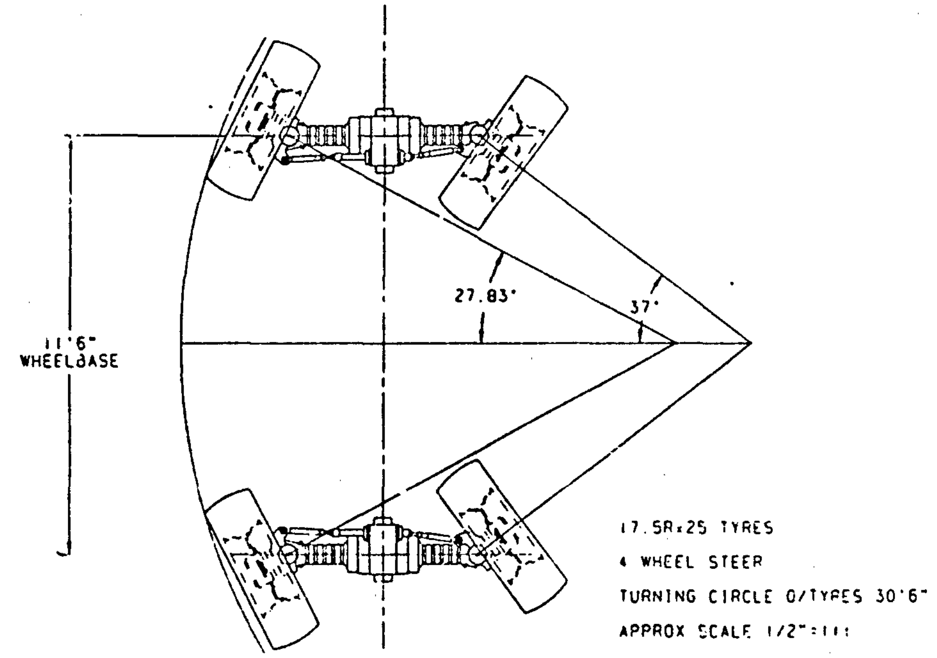


Figure 5.2.5.2-3

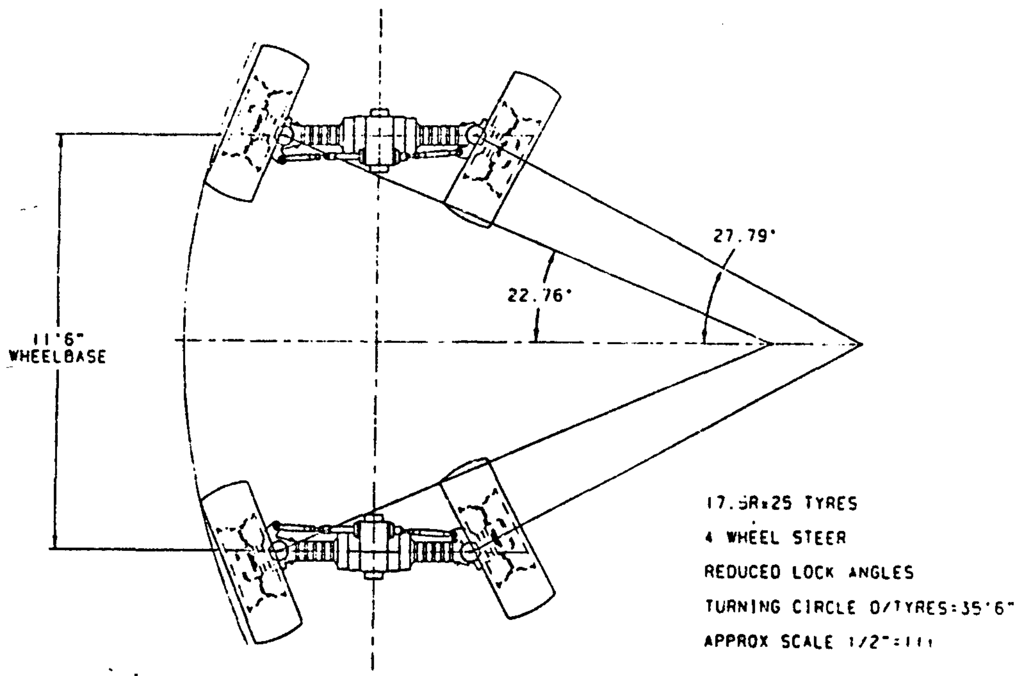


Figure 5.2.5.2-4

5.2.6 Frame Level. The operator will be able to level the chassis frame in the lateral plane to approximately ≥ 7.5 degrees from the cab. Leveling of the frame may be accomplished with the travel suspension locked.

5.2.7 Considerations-Corrosion. The structural elements of the suspension group and cylinders will be coated with the zinc-rich primer to provide the desired corrosion resistance.

Corrosion protection for the cylinder rods will be provided by chrome plate. The chrome must be of sufficient thickness (0.016 in. minimum after polishing) and uniformity to provide the desired level of protection. Adequate substrate hardness must be provided to minimize spalling of the chrome plate.

5.3 Performance.

An elastic suspension is required to meet ATLAS requirements for speed.

5.3.1 Capacity. Implementation of the hydro-pneumatic/leaf spring suspension does not compromise the capacity of the vehicle.

5.3.2 Weight (Total and Distribution). The elastic suspension adds substantial weight, approximately 2500 lbs., to the Gross Vehicle Weight (GVW). The weight is added low on the vehicle, lowering the Center of Gravity (CG).

5.3.3 Fuel Consumption. The elastic suspension increases fuel consumption only to the extent that it adds to the GVW.

5.3.4 Speed. The weight added by the elastic suspension is within the projected weight of ATLAS to meet the 50 mph requirement.

5.3.5 Vehicle Height. The vehicle height is very sensitive to the configuration and vertical space claim of the elastic suspension, hence strong space efficient leaf springs on the rear axle and dual-purpose, hydro-pneumatic springs on the front axle are desirable.

5.3.6 Ground Clearance. The ground clearance is not compromised by the suspension system.

5.4 HFE/Safety.

Implementation of an elastic suspension and the redundant mechanical steering system is critical to the safe and reliable operation of ATLAS at highway speeds.

5.4.1 Suspension. ATLAS convoy and dash speed requirements establish the requirements for suspension. The effectiveness of the ATLAS suspension can be documented with absorbed power and acceleration measurements that will identify ride quality.

Maturation of the ATLAS design could establish a requirement for a suspended seat at vehicle speeds above 20 mph.

5.4.2 Absorbed Power. Absorbed power measured in terms of watts is the descriptive parameter that correlates human response (comfort/performance) to a mechanical vibration. Absorbed power characterizes vibrations monitored in three planes which is the energy flow to and dampened by the human body. The energy flow is the result of the complex dampened, elastic properties of the human body.

ISO Standard 2631 establishes three levels of vibration exposure to define the human response in order of increasing severity:

i) Reduced Comfort Boundary,
ii) Fatigue Boundary, and
iii) Exposure Limit.

i) Reduced Comfort Boundary. The vibration frequency, acceleration, and exposure time at which the operator experiences a reduction in comfort.

ii) Fatigue Boundary. The fatigue boundary establishes the level at which the operator proficiency decreases (ie the vibration frequency, acceleration, and exposure time) at which time that there is a significant risk of impaired working efficiency.

iii) Exposure Limit. The vibration frequency, acceleration, and exposure time at which there is a significant risk to health and safety.

5.4.3 Evaluation. The instrumented ATLAS will traverse a number of courses from 0.5 to 3 inch rms. The vehicle velocity is typically presented at each roughness condition (rms) when the power is 6 watts.

5.4.4 Acceleration. Acceleration, measured in terms of gravity (gs), is the descriptive parameter that correlates human response (performance) to a single shock load introduced as the vehicle encounters a bump.

Evaluation. The instrumented ATLAS will traverse a number of bump courses at various speeds. The bump is defined as a quarter or half-round radius. The vehicles velocity will be presented at each encounter when the acceleration is +/- 5 gs and plotted. The speed data will be plotted with respect to the bump diameter.

5.5 Reliability.

The suspension and steering group must be reliable, hence a reliability allocation of 10,000 hours for a mission critical failure is provided. The complexity of the system necessitates that individual components be exceedingly reliable.

5.5.1 Cylinders-Hydraulic. Reliability of the hydraulic cylinders is typically the primary source of unreliability as a result of oil leaks. Other than mechanical damage to the cylinder rod that damages the seals, most damage to the rod seals occurs due a third particle intrusion.

The fording environment provides a number of sources for 3rd particles. Corrosion products, resulting in pitting of the rod, are generated as a result of inadequate plating thickness. The 3rd particles, sand and debris, are suspended in the surf zone. Hydraulic cylinders (Figure 5.5.1-1) suitable for sustained fording operations required a wiper seal to prevent the 3rd particles from coming into contact with the rod seals.

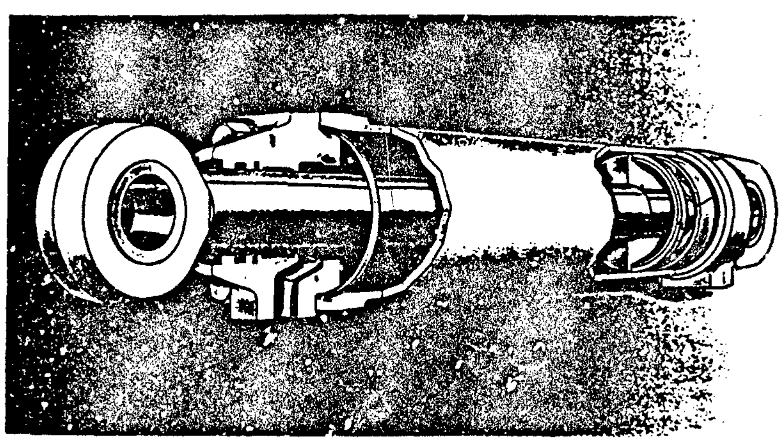


Figure 5.5.1-1 Hydraulic Cylinders

5.5.2 Springs-Leaf. To assure long term reliability, leaf springs must be inspected and lubricated on a regu[illegible] sis.

The relative motion of the leaf spring provides for a localized pumping action that will over a period of time result in erosion corrosion of the springs. The erosion rate will be aggravated by third particle wear.

The surf zone provides an unlimited source of abrasive third particles suspended in the water. The pumping action between the leaves of the spring provides the velocity for the localized erosion. Consideration may be given to replacement of the springs based upon number and duration of LOTS operation or based upon a specific (localized) reduction in leaf thickness.

The springs should be inspected for spalling of the CARC top coat and repaired as required.

5.5.3 Steering-Mechanical. The mechanical steering provides a redundant steering mechanism to the all-hydraulic system. This redundancy is central to achieving the desired mission reliability.

5.6 Producibility.

Other than the incremental costs associated with procurement and assembly of hydraulic cylinders, accumulators, carriage, and other elements of the hydraulic system, the suspension group is an assembly of off-the-shelf components tailored to the ATLAS requirements.

5.7 Cost Impact.

The cost increase associated with the more complicated suspension system required for the 50 mph road speed is approximately $10,000. Two alternatives are offered for the front suspension (leaf spring or hydro- pneumatic) with the leaf spring representing a relatively high initial cost with low complexity and maintenance. The hydro-pneumatic suspension offers a lower initial cost, but higher complexity and maintenance costs. Three alternatives are offered for the rear suspension design (A-Frame, Transverse spring or rear springs). The A-Frame represents a higher cost, with correspondingly increased performance, from the alternative suspensions.

5.8 Integrated Logistic Support.

All alternative suspensions offer proven designs with high reliability/availability. Leaf spring suspension may be more susceptible to reliability problems from third particle erosion when conducting LOTS operations. The hydro-pneumatic suspension, offering excellent performance, will generally be less reliable that simple leaf springs, but should be less susceptible to 3rd particle erosion. The slight increase in maintenance necessary should not have an appreciable effect on life cycle maintenance costs. All alternatives fit well within the maintainability and reliability requirements of MIL-T-53038 (ME).

Paragraph 6.0
Powertrain

6.1 Baseline Description

The baseline description establishes the powertrain arrangement of the RT100 from which the alternative ATLAS designs evolve.

6.1.1 Transmission. The RT100 has a 4-speed full powershift transmission.

6.1.2 Transmission Controls. A single twist-grip control on the left side of the steering wheel allows the operator to change gears or direction easily. This electric control eliminates typical mechanical linkages for increased reliability and reduced maintenance. The control valve is externally mounted on top of the transmission for easy access and quick-disconnect pressure taps are provided to ease troubleshooting.

Full clutch modulation for all shifts increases durability and provides smooth gear shifts and directional changes. On-the-go power reversals can be made up to 5 mph (9 km/h) for increased productivity. Large diameter, high energy clutch packs provide excellent performance and long life.

A standard variable-output back-up alarm sounds whenever the transmission is shifted into reverse. Neutral start prevents starting the engine with the transmission in gear.

6.1.3 Speed. Four speeds forward and reverse allow closer gear ratios for smoother shifts than competitive 3-speed transmissions. More speed ranges can also mean a faster top travel speed or a lower first gear for better gradeability.

Gear	*Direction*	*Ratio*	*Top Travel Speed*
1st	*Forward*	*4.00*	*4 mph (6 km/h)*
2nd	*Forward*	*2.17*	*7 mph (11 km/h)*
3rd	*Forward*	*1.20*	*12 mph (19 km/h)*
4th	*Forward*	*0.78*	*19 mph (31 km/h)*
1st	*Reverse*	*3.68*	*4 mph (6 km/h)*
2nd	*Reverse*	*2.00*	*7 mph (12 km/h)*
3rd	*Reverse*	*1.10*	*13 mph (21 km/h)*
4th	*Reverse*	*0.72*	*21 mph (33 km/h)*

6.1.4 Transmission Lube and Cooling System. The large 30 qt (28 L) capacity lube system and a large plate-type oil cooler in the bottom of the radiator help keep oil temperatures low to increase transmission life. The oil is circulated by a gear pump which is externally mounted on the transmission for easier service access. The spin-on oil filter is shielded by a guard for protection from damage. A by-pass valve in the filter base ensures lubrication during cold starts or in case the filter gets plugged.

6.1.5 Transmission Interface. The transmission is remote-mounted from the engine in the middle of the chassis. A gear box provides the flywheel input for the transmission, a slight drop between the engine output and transmission input shafts and a centrally located hydraulic pump drive.

A torsional-damped drive shaft transfers power from the engine to the gear box. This shaft is connected to the engine and gear box with large rubber collars to isolate the transmission and gear box from the engine's torsional vibrations. Drive shafts with conventional universal joints connect the transmission to the drive axles.

Full-time 4-WD is standard. The identical front and rear axle ratios and equal size tires make a 4-WD disconnect unnecessary. However, tight turns on hard pavement should be minimized to extend tire tread life.

6.1.6 Axles. The RT100 has planetary drive axles front and rear. The RT100 has a large axle to accommodate the vehicle weight and lift capacity. These double reduction axles have the initial gear reduction in the differential and the final reduction in the planetary hubs. The outboard planetary design reduces stress on the differential, axle shafts and axle shaft universal joints. In addition, it helps absorb shocks, and it reduces axle shaft wind-up and wheel chatter for continuous traction. It also provides a more compact differential housing which increases ground clearance.

Both axles have 4-pinion differentials. Distributing the torque through four gears instead of two reduces the gear loads for greater reliability and longer life.

The front axle differential lock increases traction by ensuring power is transferred to both front wheels. Normally, the differential allows the right and left wheels to turn at different speeds to reduce tire scrubbing when turning on hard surfaces. However, it also allows all the power to go to the tire with the least traction causing it to spin. The differential lock overrides normal differential operation and rigidly connects the two front wheels. The differential lock is actuated by a foot switch, and normal operation is restored when the switch is released.

6.1.7 Brakes. Both axles feature fully enclosed, inboard mounted, oil disc brakes. This design provides longer service life and reduced potential for contamination when compared to external disc brake or expanding shoe brake designs. Each axle has ten brake discs, with a total contact area of 338 sq in (2180 sq cm). With brakes on both axles, the brake system has a total of twenty brake discs with a total area of 676 sq in (4360 sq cm). Distributing the braking loads over such a large area helps reduce heat build-up and wear for longer brake life.

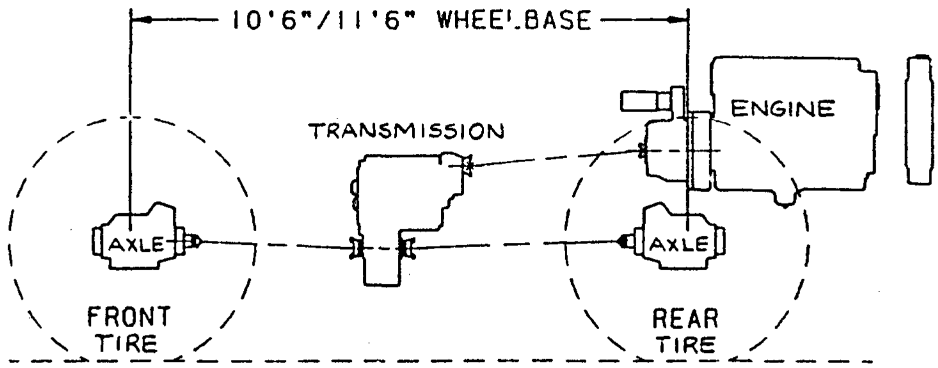
The RT100 provides full power brakes for excellent braking performance with low pedal effort. The hydraulic pump supplies pressurized oil to the brake system charge valve, which in turn stores oil in the accumulator at 2320 psi (160 bars). When the brake pedal is depressed, the power valve releases oil from the accumulator to actuate the brake discs in both axles. Pressure in the brake lines is proportional to brake pedal movement, so the further the brake pedal is depressed the harder the brakes are applied. The pressure in the brake lines is transmitted back to the brake pedal to give

the operator "brake feel". The accumulator is normally recharged after each stop. If a system malfunction allows the pressure in the accumulator to fall to 1800 psi (124 bars), a warning buzzer alerts the operator. The accumulator can provide up to ten more stops after the buzzer sounds.

6.1.8 Brake-Parking. The hand-actuated parking brake mechanically actuates the service brake discs in the front axle. An interlock neutralized the transmission when the park brake is applied to prevent driving through the parking brake for longer brake life. There is an adjustment on the parking brake handle to compensate for cable stretch to make it easier to keep the parking brake adjusted properly.

6.2 Alternative Design.

ATLAS necessitates that the commercial powertrain be redesign to meet the speed requirements. Figure 6.2-1 provide approximate location of powertrain components and brief summary of requirements.



MACHINE SPEC	ALL TERRAIN VARIABLE REACH FORK LIFT TRUCK. MAX WIDTH 8'5" OR 9'0". WEIGHT 32250 lb UNLADEN. WEIGHT 42250 lb LADEN. ON ROAD SPEED (4x2) 50MPH UNLADEN. OFF ROAD PERFORMANCE (4x4) 2MPH UP 45% GRADE LADEN. OFF ROAD MAX SPEED 20/25MPH UNLADEN.
ENGINE	6 CYL DIESEL TURBO-CHARGED. 247 HP AT 2400 RPM NET.
POWER SHIFT TRANSMISSION	TORQUE CONVERTOR WITH LOCK UP. 6 OR 8 SPEED. HYDRAULIC PUMP P.T.O.
AXLES	STEER/DRIVE-OIL IMMERSED BRAKES HUB REDUCTION, HYD/MECH STEERING. O/ALL RATIO ≏ 10 TO 1. MAX STATIC AXLE LOAD 44750 lb; AT 50MPH 18000 lb.
TYRES	17.5x25 OR 20.5x25 PNEUMATICS. SINGLES.
SUSPENSION	ON ROAD- BOTH AXLES SPRUNG. OFF-ROAD- FRONT-RIGID, REAR-CENTRE PIVOT OR SPRUNG

Figure 6.2-1 Powertrain Components Location & Summary of Requirements

6.2.1 Engine. ATLAS engine considerations are addressed in paragraph 2.0. To maintain universal joints speed below 3500 rpm, maximum engine speed is limited to 2610 rpm at (No Load) and2400 rpm @ 270 HP.

6.2.2 Transmission. Various transmission arrangements have been reviewed with respect to ATLAS to meet the duty cycle with the 50 mph dash speed:

a) Clark 3200 Series Transmission with CL320 Series Converter rated at 250 HP,
b) Clark 3400 Series Transmission with 2-speed transfer case rated at 300 HP
c) Allison MD 3070 World Transmission rated at 300 HP,
d) Allison MD 3560 with 2-speed transfer case (w/retarder) rated at 300 HP,
e) ZF Powershift Reversing Transmission rated at 300 HP.

Mounting of the transr. ission (remote or engine) will be determined with maturation of the ATLAS design.

6.2.2.1 Clark Transmissions. The Speed vs Tractive Force for each of the two transmissions (250 and 300 HP) arrangements are defined in Figure 6.2.2.1 -1.

Clark provided a number of analyses of ATLAS powertrain that are submitted for review (Table 6.2.2.1 located at the back of this section).

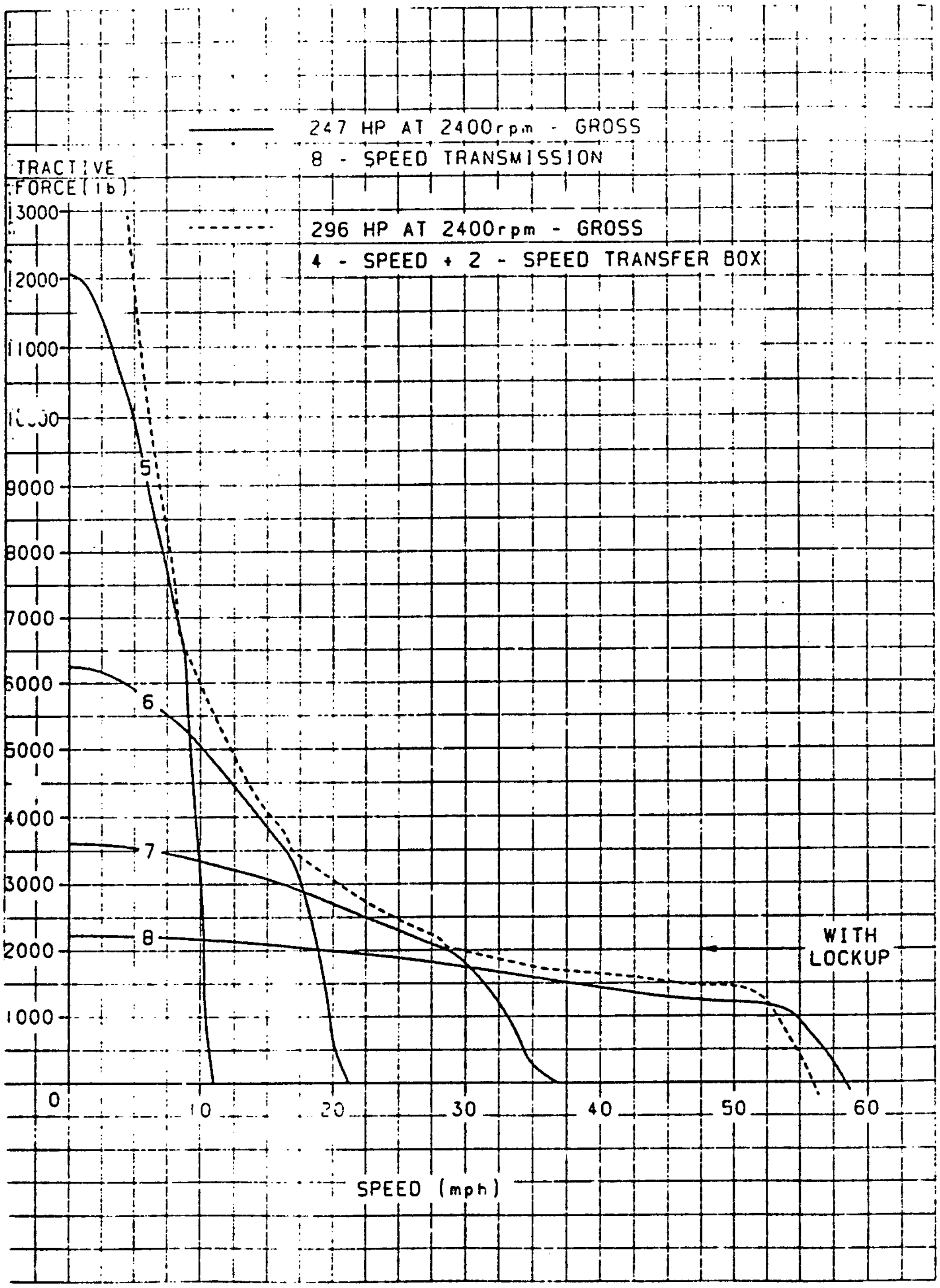


Figure 6.2.2.1-1 Clark Transmissions

6.2.2.2 Allison Transmissions. The MD3070 WT Transmission used in the FMTV Program provides a 300 HP capability, but the range of gears 0.783 to 6.929 and the offset of the outputs are not suitable for RTFL applications. Alternately the MD3560 with as 2-speed transfer case may be suitable. This arrangement allows the use of a retarder to assist in braking from highway speeds.

Allison provided a number of analyses of the ATLAS powertrain. These are summarized in Figure 6.2.2.2-1 with Table 6.2.2.2-1 (located at the back of this section) providing supporting documentation.

ATLAS 4 X 4

SCAAN REF	G.V.W. lbs	H.P.	DRIVELINE RATIO	TYRE SIZE	STALL GRADE % 1st GEAR	GRADE % @ 2 MPH 1st GEAR	GRADE % @ 2 MPH REVERSE
326077	42000	300	11.099	20.5 X 25	148	77	65
326078	42000	250	11.095	20.5 X 25	131	64	56
326079	42000	225	11.095	20.5 X 25	126	62	54
326080	42000	300	10.106	17.5 X 25	148	77	65
323447	42000	250	10.102	17.5 X 25	131	64	56
323449	42000	225	10.102	17.5 X 25	126	62	54

Figure 6.2.2.2-1 Allison Transmission Summary

6.2.2.3 ZF Transmissions. Insufficient data was submitted by ZF to establish the feasibility of this manufacturer's transmissions.

6.2.3 Axles. Any steerable axle selected for ATLAS requires modification to meet the steering and suspension requirements and are addressed within Section 5.0 of this report.

The maximum static and dynamic axle loads are projected to be 44,750 and 18,000 lbs respectively. Maximum dynamic loads are predicted to occur during 58 mph operations.

An overall powertrain ratio of 10:1 with 20.5Rx15 tires is required to provide the desired speed. Commercial axles will require modification to provide this powertrain ratio.

Final selection of the axle is required to consider vehicle width and transportability requirements. The Clark-Hurth 276 series axle provides the baseline axle arrangement for the C130 transportability study. Alternately Spicer has recommended the PS 1350 series axle. ZF and Rockwell have been solicited, but did not respond.

6.2.4 Braking. Viable brake options to meet the ATLAS operational requirements for fording were rapidly reduced to enclosed wet disc brakes.

Dry brakes, either caliper disc or drum brakes, are very sensitive to corrosion. In addition to corrosion, caliper disc brakes are totally exposed to a very abrasive environment that wears the pads and discs. Drum brakes typically implement a labyrinth seal to minimize ingestion of abrasive particles. Alternately, the same labyrinth seal would retain 3rd particles ingested during fording; again the drums and brake pads would abrade readily.

Enclosed brakes are offered on a variety of axle arrangements including Hurth (inboard disc) and Spicer (outboard disc). They are environmentally sealed hence braking performance is not compromised.

<u>6.2.4.1 Performance.</u> Braking performance is strongly influenced by the increased weight, speed, and braking efficiency of ATLAS over the commercial RTFLs. The heat dissipation properties of the brakes must be monitored with maturation of the ATLAS design.

Preliminary performance targets have been established for this study; Table 6.2.4.1-1 provide preliminary calculations. The service brakes should be able to decelerate the unladened vehicle at 14.5 ft/sec^2 from highway speeds with 45% efficiency requiring 15540 lbs brake torque per axle at the wheels.

Parking brakes should be able to hold a ladened and unladened vehicle on grades of 25% and 33% respectively. Figures 6.2.4.1-1 provide force requirements vs brake torque. Note that the brake torque required exceed capability of the commercial brakes with 12 discs and an applied force of 1300 lbs force.

The braking system at a minimum should provide for a dual circuit, hydraulically powered service brake and a spring-applied, hydraulically-released parking brake.

Table 6.2.2.1

H. 11:00

CLARK Harlow Customer : BROWN DESIGN
Application : 5T BOOM LIFT TRUCK

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pump drive ratio : 0.951
36.99 GPM @ 2000 rpm & 100.0 psi = 12.72 #' MAIN/STEER
21 GPM @ 2000 rpm & 250.0 psi = 12.0_ #' charging pump
Total non-std accessories : = 24.80 #'

hgS

			ratios :	(range shift) FWD	REV
CAT	CL323.5 (TD)	R28825			
3116				9.94	9.94
converter				5.16	5.16
stall at				2.97	2.97
477 #ft @2308				1.84	1.84
				4.02	4.02
				2.09	2.09
				1.20	1.20
				0.74	0.74

Rotation : opposite engine (transm. FWD-clutch engaged)

curb vehicle weight = 32325 lbs
gross vehicle weight = 32325 lbs
weight on drivers = 32325 lbs
gross train weight = 32325 lbs

axle reduction : 9.250
rolling radius : 25.71 inch
tire size: 20.5RX25

Engine curve no. date :
Net engine HP = gross HP less 10.0 % deduction for standard engine accessories
Converter input torque = net engine torque less 24.80 #' for non-std access.
Engine overrun 10.0 % (1HP = .746 kW)

	engine RPM	engine Gross HP	engine Net HP	engine Net Torque	converter Input Torque
No load gov'd	2640	0	0	0	-24.8 #'
Full load gov'd	2400	247	222	485.6 #'	460.8 #'
	2200	241	217	517.1 #'	492.3 #'
	1800	213	192	559.4 #'	534.6 #'
	1500	181	163	571.9 #'	547.1 #'

Peak gross engine torque = 635.4 #' at 1500 rpm

SPEED=TURB.RPMx(25.71" ROL.RAD.)/(168xTR.RAT.x(9.250 A.R.))
TE=TURB.TQxTR.RAT.x(9.250 A.R.)x(80.0% EFF.)/(25.71" ROL.RAD.)

* Max. speeds calculated assuming 20/1000 rolling resist., 10850.0 square in frontal area, air res. coeff: 0.000017 lbs per (MPH)squared per square in
* Tractive effort and % grade are with converter at stall
* % grade is calculated with gross train weight

	GROSS TRAIN WT	EMPTY VEHICLE	*	TRACTIVE EFFORT	% GRADE
Gear no 1 =	4.40 mph	4.40 mph	*	29829 lbs	209.9
Gear no 2 =	8.39 mph	8.39 mph	*	15466 lbs	51.6
Gear no 3 =	14.27 mph	14.27 mph	*	8924 lbs	26.5
Gear no 4 =	22.51 mph	22.51 mph	*	5519 lbs	15.2
Gear no 5 =	10.67 mph	10.67 mph	*	12071 lbs	37.8
Gear no 6 =	19.96 mph	19.96 mph	*	6257 lbs	17.6
Gear no 7 =	33.48 mph	33.48 mph	*	3612 lbs	9.2
Gear no 8 =	48.78 mph	48.78 mph	*	2232 lbs	4.9

Tractive effort required to slip wheels : (32325)x(0.60 coeff.) = 19395 lbs
Converter efficiency at wheel slip in gear no 1 = 91.4 % (1.17 torque ratio)
Stall tractive effort relationship to GVW : 29829/ 32325 = 0.923

THIS DOCUMENT IS FOR PERFORMANCE COMPARISON PURPOSE ONLY AND MUST NOT BE CONSIDERED AS APPROVAL OF COMPONENTS, ADAPTATION OR OPTIONS WHICH IS SUBJECT TO BRUGGE APPLICATION ENGINEERING REVIEW.

Approval no. BDE 3
CLARK Componente Europe

29 NOV 91 sheet 2 of 4
ST BOOM LIFT TRUCK

DRIVELINE DESCRIPTION

Engine : CAT 3116 247 HP at 2400 rpm
Converter : CL323.5 Thru drive
Transmission : R28825

CALCULATED TORQUE CONVERTER PERFORMANCE
Per curve no. PA13-18

Charging pump flow less an estimated flow of 3.5 GPM clutch pressure supply and converter lubrication equals the approximate oil flow to cooler

Pt no	Speed ratio	Torque ratio	Conv. eff.	Converter input RPM	Converter input TQ #'	Converter input HP	Converter Turbine RPM	Converter Turbine TQ #'	Converter Turbine HP	Conv.Cooling GPM	Conv.Cooling HP *
1	0.000	1.820	0.0	2308	476.9	209.6	0	868.0	0.0	22.0	209.6
2	0.100	1.778	17.8	2257	484.7	208.3	226	861.9	37.0	21.4	171.3
3	0.200	1.725	34.5	2223	489.3	207.1	445	844.1	71.5	21.0	135.7
4	0.300	1.657	49.7	2201	492.2	206.2	660	815.5	102.5	20.8	103.7
5	0.400	1.575	63.0	2183	494.3	205.5	873	778.5	129.5	20.6	76.0
6	0.458	1.529	70.0	2175	495.3	205.1	996	757.3	143.6	20.5	61.5
7	0.500	1.494	74.7	2171	495.8	204.9	1085	740.7	153.1	20.5	51.9
8	0.600	1.392	83.5	2169	496.0	204.9	1302	690.5	171.1	20.5	33.8
9	0.700	1.274	89.2	2197	492.6	206.1	1538	627.6	183.8	20.8	22.3
10	0.750	1.210	90.7	2232	488.2	207.4	1674	590.7	188.3	21.1	19.2
11	0.800	1.144	91.5	2300	478.2	209.4	1840	547.0	191.7	21.9	17.8
12	0.850	1.071	91.0	2374	465.7	210.5	2018	498.8	191.6	22.7	18.9
gov>	0.867	1.046	90.6	2400	460.8	210.6	2080	481.9	190.9	23.0	19.7
13	0.900	0.989	89.0	2444	427.4	198.8	2199	422.7	177.0	23.5	21.9
14	0.950	0.863	82.0	2515	300.9	144.1	2389	259.7	118.1	24.3	26.0
15	0.970	0.758	73.5	2573	165.6	81.1	2495	125.5	59.6	24.9	21.5
16	0.973	0.719	70.0	2582	141.7	69.7	2513	101.9	48.8	25.0	20.9
17	1.020	0.000	0.0	2624	23.1	11.6	2677	0.0	0.0	25.5	11.6

*: Does not consider transmission mechanical efficiency

- Heat exchanger capacity required is minimum 30 % of maximum engine power or more when necessary to keep conv. outlet temp. between 80 and 120 deg C in all conditions (working, travelling, etc. in all ambient temperatures).
- It is not allowed to run the vehicle downhill faster than the maximum speeds indicated for each gear -see vehicle performance page(s).

A

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CLARK Components Europe 5T BOOM LIFT TRUCK

DRIVELINE DESCRIPTION

Engine	: CAT	3116	247 HP at 2400 rpm
Converter	: CL323.5	Thru drive	
Transmission	: R28825		
Axle ratio	: 9.250		
Tire size	: 20.5RX25	Rolling radius : 25.71 in	(Static, loaded)

CALCULATED VEHICLE PERFORMANCE IN CONVERTER DRIVE

% Grade based on GTW, assuming 20/1000 rolling resistance, 10850.0 square in frontal area, air res. coeff: 0.000017 lbs per (MPH)squared per square in

low range

Pt	GEAR NO 1	RATIO = 9.944		GEAR NO 2	RATIO = 5.156		GEAR NO 3	RATIO = 2.975		GEAR NO 4	RATIO = 1.840	
no	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %
1	0.0	29829	209.9	0.0	15466	51.6	0.0	8924	26.5	0.0	5519	15.2
2	0.4	29617	202.0	0.7	15357	51.1	1.3	8861	26.3	2.0	5480	15.1
3	0.7	29006	182.8	1.4	15040	49.7	2.5	8678	25.6	4.0	5367	14.8
4	1.1	28025	159.3	2.1	14531	47.6	3.7	8384	24.6	5.9	5186	14.2
5	1.5	26754	137.0	2.8	13872	44.8	4.9	8004	23.4	7.9	4951	13.4
6	1.7	26025	126.8	3.2	13494	43.3	5.5	7786	22.6	9.0	4816	13.0
7	1.8	25455	119.7	3.5	13198	42.1	6.0	7615	22.1	9.8	4710	12.6
8	2.2	23727	102.0	4.2	12303	38.6	7.2	7099	20.3	11.7	4390	11.6
9	2.6	21566	84.9	4.9	11182	34.5	8.6	6452	18.2	13.8	3991	10.3
10	2.8	20300	76.6	5.4	10526	32.1	9.3	6073	17.0	15.1	3756	9.5
11	3.1	18799	67.9	5.9	9747	29.3	10.2	5624	15.5	16.6	3478	8.6
12	3.4	17140	59.3	6.5	8887	26.3	11.2	5128	13.9	18.2	3172	7.6
GOV>	3.5	16561	56.6	6.7	8587	25.3	11.6	4955	13.4	18.7	3064	7.3
13	3.7	14525	47.5	7.1	7531	21.8	12.2	4346	11.4	19.8	2688	6.1
14	4.0	8924	26.5	7.7	4627	12.4	13.3	2670	6.2	21.5	1651	2.8
15	4.2	4312	11.4	8.0	2236	4.9	13.9	1290	1.9	22.5	798	0.2
16	4.2	3503	8.9	8.1	1816	3.6	14.0	1048	1.1	22.6	648	0.0
17	4.5	0	0.0	8.6	0	0.0	14.9	0	0.0	24.1	0	0.0

THEORETICAL TRANSMISSION SHIFT POINTS (TURBINE RPM), ENGINE AT FULL THROTTLE

1 > 2 : 2270	2 > 3 : 2230	3 > 4 : 2210
2 < 1 : 1170	3 < 2 : 1290	4 < 3 : 1370

hi range

Pt	GEAR NO 5	RATIO = 4.024		GEAR NO 6	RATIO = 2.086		GEAR NO 7	RATIO = 1.204		GEAR NO 8	RATIO = 0.744	
no	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %
1	0.0	12071	37.8	0.0	6257	17.6	0.0	3612	9.2	0.0	2232	4.9
2	0.9	11985	37.5	1.8	6213	17.5	3.1	3586	9.1	5.0	2216	4.8
3	1.8	11738	36.5	3.5	6085	17.1	6.1	3512	8.9	9.9	2170	4.7
4	2.7	11341	35.1	5.2	5879	16.4	9.1	3393	8.5	14.7	2097	4.4
5	3.6	10827	33.2	6.9	5612	15.5	12.0	3239	8.0	19.4	2002	4.0
6	4.1	10532	32.1	7.9	5459	15.0	13.7	3151	7.7	22.2	1947	3.7
7	4.5	10301	31.3	8.6	5340	14.6	14.9	3082	7.4	24.2	1905	3.6
8	5.4	9602	28.8	10.3	4977	13.5	17.9	2873	6.7	29.0	1775	3.0
9	6.3	8727	25.8	12.2	4524	12.0	21.1	2611	5.8	34.2	1614	2.3
10	6.9	8215	24.1	13.3	4258	11.1	23.0	2458	5.3	37.2	1519	1.9
11	7.6	7607	22.0	14.6	3943	10.1	25.3	2276	4.7	40.9	1406	1.4
12	8.3	6936	19.8	16.0	3596	9.0	27.7	2075	4.0	44.9	1282	0.8
GOV>	8.6	6702	19.0	16.5	3474	8.6	28.6	2005	3.7	46.3	1239	0.6
13	9.0	5878	16.3	17.5	3047	7.3	30.2	1759	2.9	48.9	1087	0.0
14	9.8	3611	9.2	19.0	1872	3.6	32.9	1080	0.7	53.2	668	0.0
15	10.3	1745	3.3	19.8	905	0.6	34.3	522	0.0	55.5	323	0.0
16	10.3	1417	2.3	19.9	735	0.0	34.5	424	0.0	55.9	262	0.0
17	11.0	0	0.0	21.2	0	0.0	36.8	0	0.0	59.6	0	0.0

THEORETICAL TRANSMISSION SHIFT POINTS (TURBINE RPM), ENGINE AT FULL THROTTLE

5 > 6 : 2270	6 > 7 : 2230	7 > 8 : 2210
6 < 5 : 1170	7 < 6 : 1290	8 < 7 : 1360

H

Approval no. BDE 3
CLARK Components Europe

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ST BOOM LIFT TRUCK

DRIVELINE DESCRIPTION

Engine	: CAT	3116	247 HP at 2400 rpm
Converter	: CL323.5	Thru drive	
Transmission	: R28825		
Axle ratio	: 9.250		
Tire size	: 20.5RX25	Rolling radius : 25.71 in	(Static, loaded)

CALCULATED VEHICLE PERFORMANCE IN LOCKUP

% Grade based on GTW, assuming 20/1000 rolling resistance, 10850.0 square in frontal area, air res. coeff: 0.000017 lbs per (MPH)squared per square in

low range

	GEAR NO 1	RATIO = 9.944		GEAR NO 2	RATIO = 5.156		GEAR NO 3	RATIO = 2.975		GEAR NO 4	RATIO = 1.840	
Turb RPM	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %
1500	2.5	18535	66.4	4.8	9611	28.8	8.3	5545	15.3	13.5	3430	8.5
1680	2.8	18306	65.2	5.4	9491	28.4	9.3	5477	15.1	15.1	3387	8.4
1860	3.1	17801	62.6	6.0	9230	27.5	10.3	5326	14.6	16.7	3294	8.1
2040	3.4	17090	59.1	6.5	8861	26.2	11.4	5113	13.9	18.4	3162	7.6
2220	3.7	16261	55.2	7.1	8432	24.8	12.4	4865	13.1	20.0	3009	7.1
2400	4.0	15172	50.3	7.7	7867	22.9	13.4	4539	12.0	21.6	2807	6.4
2448	4.1	13809	44.6	7.9	7160	20.5	13.6	4131	10.7	22.0	2555	5.6
2496	4.2	10944	33.6	8.0	5675	15.7	13.9	3274	8.0	22.5	2025	4.0
2544	4.2	7411	21.4	8.2	3843	9.9	14.2	2217	4.7	22.9	1371	1.9
2592	4.3	3210	7.9	8.3	1665	3.1	14.4	960	0.8	23.3	594	0.0
2640	4.4	-1658	0.0	8.5	-860	0.0	14.7	-496	0.0	23.8	-307	0.0

	GROSS TRAIN WT	EMPTY VEHICLE	Max speed in
Gear no 1 =	4.36 mph	4.36 mph	*
Gear no 2 =	8.39 mph	8.39 mph	*
Gear no 3 =	14.48 mph	14.48 mph	*
Gear no 4 =	23.24 mph	23.24 mph	*

hi range

	GEAR NO 5	RATIO = 4.024		GEAR NO 6	RATIO = 2.086		GEAR NO 7	RATIO = 1.204		GEAR NO 8	RATIO = 0.744	
Turb RPM	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %
1500	6.2	7501	21.7	11.9	3888	10.0	20.6	2244	4.7	33.4	1387	1.6
1680	6.9	7408	21.4	13.3	3840	9.8	23.1	2216	4.5	37.4	1370	1.4
1860	7.7	7204	20.7	14.8	3734	9.5	25.6	2155	4.3	41.4	1332	1.1
2040	8.4	6916	19.7	16.2	3585	9.0	28.0	2069	3.9	45.4	1279	0.7
2220	9.1	6580	18.6	17.6	3411	8.4	30.5	1969	3.5	49.4	1217	0.3
2400	9.9	6139	17.2	19.0	3183	7.7	33.0	1837	3.0	53.4	1135	0.0
2448	10.1	5588	15.4	19.4	2897	6.8	33.7	1672	2.5	54.5	1033	0.0
2496	10.3	4429	11.7	19.8	2296	4.9	34.3	1325	1.4	55.5	819	0.0
2544	10.5	2999	7.2	20.2	1555	2.6	35.0	897	0.1	56.6	555	0.0
2592	10.7	1299	2.0	20.6	673	0.0	35.6	389	0.0	57.7	240	0.0
2640	10.9	-671	0.0	21.0	-348	0.0	36.3	-201	0.0	58.7	-124	0.0

	GROSS TRAIN WT	EMPTY VEHICLE	Max speed in
Gear no 5 =	10.73 mph	10.73 mph	*
Gear no 6 =	20.55 mph	20.55 mph	*
Gear no 7 =	35.00 mph	35.00 mph	*
Gear no 8 =	52.34 mph	52.34 mph	*

Lock-up to be engaged and disengaged at 2013 turbine RPM when engine is at full throttle.

CLARK Harlow

Customer : BROWN DESIGN
Application : 5T BOOM LIFT TRUCK

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pump drive ratio : 1.000
36.99 GPM @ 2000 rpm & 100.0 psi = 12.10 #' MAIN/STEER
31 GPM @ 2000 rpm & 250.0 psi = 16.96 #' charging pump
Total non-std accessories : = 29.06 #'

CAT 3116 converter stall at 648 #ft @1774	15.5LHR34414 ratios :	(full powershift) FWD	REV	
CAT	ratios :	FWD	REV	
3116		5.32	5.32	
converter		2.66	2.62	transfercase
stall at		1.51	1.51	
648 #ft @1774		0.86	0.86	

ratios :
1.90
0.90

Rotation : opposite engine (transm. FWD-clutch engaged)

curb vehicle weight = 32325 lbs
gross vehicle weight = 32325 lbs
weight on drivers = 32325 lbs
gross train weight = 32325 lbs

axle reduction : 9.250
rolling radius : 25.71 inch
tire size: 20.5RX25

Engine curve no. date :
Net engine HP = gross HP less 10.0 % deduction for standard engine accessories
Converter input torque = net engine torque less 29.06 #' for non-std access.
Engine overrun 10.0 % (1HP = .746 kW)

	engine RPM	engine Gross HP	engine Net HP	engine Net Torque	converter Input Torque
No load gov'd	2640	0	0	0	-29.1 #'
Full load gov'd	2400	296	266	582.8 #'	553.7 #'
	2200	285	257	612.4 #'	583.4 #'
	1800	256	231	673.4 #'	644.3 #'
	1500	222	200	699.3 #'	670.2 #'

Peak gross engine torque = 777.0 #' at 1500 rpm

SPEED=TURB.RPMx(25.71" ROL.RAD.)/(168xTR.RAT.xTFC.RAT.x(9.250 A.R.))
TE=TURB.TQxTR.RAT.xTFC.RAT.x(9.250 A.R.)x(80.0% EFF.)/(25.71" ROL.RAD.)

* Max. speeds calculated assuming 20/1000 rolling resist., 10850.0 square in frontal area, air res. coeff: 0.000017 lbs per (MPH)squared per square in
* Tractive effort and % grade are with converter at stall
* % grade is calculated with gross train weight

	GROSS TRAIN WT	EMPTY VEHICLE	*	TRACTIVE EFFORT	% GRADE
Transfercase ratio : 1.900					
Gear no 1 =	4.32 mph	4.32 mph	*	40300 lbs	INF.
Gear no 2 =	8.58 mph	8.58 mph	*	20146 lbs	75.6
Gear no 3 =	14.89 mph	14.89 mph	*	11466 lbs	35.5
Gear no 4 =	25.54 mph	25.54 mph	*	6516 lbs	18.5
Transfercase ratio : 0.900					
Gear no 1 =	9.04 mph	9.04 mph	*	19089 lbs	69.5
Gear no 2 =	17.78 mph	17.78 mph	*	9543 lbs	28.6
Gear no 3 =	30.23 mph	30.23 mph	*	5431 lbs	15.0
Gear no 4 =	49.41 mph	49.41 mph	*	3087 lbs	7.6

Tractive effort required to slip wheels : (32325)x(0.60 coeff.) = 19395 lbs
Converter efficiency at wheel slip in gear no 1 = 85.4 % (0.92 torque ratio)
Stall tractive effort relationship to GVW : 40300/ 32325 = 1.247

THIS DOCUMENT IS FOR PERFORMANCE COMPARISON PURPOSE ONLY AND MUST NOT BE CONSIDERED AS APPROVAL OF COMPONENTS, ADAPTATION OR OPTIONS WHICH IS SUBJECT TO BRUGGE APPLICATION ENGINEERING REVIEW.

DRIVELINE DESCRIPTION

Engine : CAT 3116 296 HP at 2400 rpm
Transmission : 15.5LHR34414

CALCULATED TORQUE CONVERTER PERFORMANCE
Per curve no. PA15-6

Charging pump flow less an estimated flow of 5.5 GPM clutch pressure supply and converter lubrication equals the approximate oil flow to cooler

Pt	Speed	Torque	Conv.	Converter	input		Converter	Turbine		Conv.Cooling	
no	ratio	ratio	eff.	RPM	TQ #'	HP	RPM	TQ #'	HP	GPM	HP *
1	0.000	1.780	0.0	1774	647.5	218.7	0	1152.6	0.0	22.0	218.7
2	0.100	1.731	17.3	1752	650.1	216.8	175	1125.2	37.5	21.6	179.3
3	0.200	1.675	33.5	1732	652.2	215.0	346	1092.5	72.0	21.3	143.0
4	0.300	1.613	48.4	1711	654.4	213.2	513	1055.5	103.2	21.0	110.0
5	0.400	1.548	61.9	1691	656.4	211.3	676	1016.1	130.9	20.7	80.5
6	0.466	1.503	70.0	1679	657.6	210.2	782	988.5	147.1	20.5	63.1
7	0.500	1.476	73.8	1673	658.1	209.6	836	971.4	154.7	20.4	54.9
8	0.600	1.388	83.3	1656	659.6	208.0	994	915.5	173.2	20.2	34.8
9	0.650	1.329	86.4	1670	658.3	209.4	1086	874.9	180.9	20.4	28.5
10	0.700	1.267	88.7	1700	655.5	212.2	1190	830.5	188.2	20.9	24.0
11	0.750	1.197	89.8	1736	651.8	215.4	1302	780.2	193.4	21.4	22.0
12	0.800	1.129	90.3	1785	646.2	219.6	1428	729.6	198.3	22.2	21.3
13	0.850	1.062	90.3	1843	638.8	224.1	1566	678.4	202.3	23.1	21.8
14	0.900	0.978	88.0	1970	620.0	232.5	1773	606.4	204.7	25.0	27.9
15	0.950	0.856	81.3	2368	558.4	251.7	2249	478.0	204.7	31.2	47.0
gov>	0.951	0.849	80.8	2400	553.7	253.0	2283	470.2	204.4	31.7	48.6
16	0.963	0.727	70.0	2531	321.1	154.8	2438	233.4	108.3	33.7	46.4
17	1.015	0.000	0.0	2620	44.0	22.0	2659	0.0	0.0	35.1	22.0

*: Does not consider transmission mechanical efficiency

- Heat exchanger capacity required is minimum 30 % of maximum engine power or more when necessary to keep conv. outlet temp. between 80 and 120 deg C in all conditions (working, travelling, etc. in all ambient temperatures).
- It is not allowed to run the vehicle downhill faster than the maximum speeds indicated for each gear -see vehicle performance page(s).

Approval no. BDE 3
CLARK Components Europe

2 DEC 91 sheet 3 of 6
5T BOCM LIFT TRUCK

DRIVELINE DESCRIPTION

Engine : CAT 3116 296 HP at 2400 rpm
Transmission : 15.5LHR34414
Axle ratio : 9.250 Transfercase ratios : 1.900 0.900
Tire size : 20.5RX25 Rolling radius : 25.71 in (Static, loaded)

CALCULATED VEHICLE PERFORMANCE IN CONVERTER DRIVE

% Grade based on GTW, assuming 20/1000 rolling resistance, 10850.0 square in frontal area, air res. coeff: 0.000017 lbs per (MPH)squared per square in

transfercase ratio : 1.900

	GEAR NO 1			GEAR NO 2			GEAR NO 3			GEAR NO 4		
	RATIO = 5.325			RATIO = 2.662			RATIO = 1.515			RATIO = 0.861		
Pt no	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %
1	0.0	40300	INF.	0.0	20146	75.6	0.0	11466	35.5	0.0	6516	18.5
2	0.3	39343	INF.	0.6	19668	72.8	1.0	11193	34.5	1.8	6361	18.0
3	0.6	38199	INF.	1.1	19096	69.5	2.0	10868	33.3	3.5	6176	17.4
4	0.8	36904	INF.	1.7	18449	66.0	3.0	10500	32.0	5.2	5967	16.7
5	1.1	35527	INF.	2.2	17760	62.4	3.9	10108	30.6	6.8	5744	15.9
6	1.3	34563	INF.	2.6	17278	60.0	4.5	9834	29.6	7.9	5589	15.4
7	1.4	33964	INF.	2.7	16979	58.5	4.8	9663	29.0	8.5	5492	15.1
8	1.6	32009	400.3	3.3	16001	54.0	5.7	9107	27.1	10.1	5175	14.1
9	1.8	30591	245.9	3.6	15292	50.8	6.2	8703	25.7	11.0	4946	13.3
10	1.9	29038	183.7	3.9	14516	47.5	6.8	8262	24.2	12.0	4695	12.5
11	2.1	27278	145.3	4.3	13636	43.9	7.5	7761	22.5	13.2	4411	11.6
12	2.3	25510	120.3	4.7	12752	40.4	8.2	7258	20.9	14.4	4125	10.7
13	2.6	23720	101.9	5.1	11858	37.0	9.0	6749	19.2	15.8	3835	9.8
14	2.9	21201	82.4	5.8	10599	32.3	10.2	6032	16.8	17.9	3428	8.4
15	3.7	16712	57.3	7.4	8355	24.5	12.9	4755	12.7	22.8	2702	6.1
GOV>	3.7	16440	56.0	7.5	8219	24.1	13.1	4677	12.5	23.1	2658	5.9
16	4.0	8160	23.9	8.0	4079	10.6	14.0	2322	5.1	24.7	1319	1.7
17	4.4	0	0.0	8.7	0	0.0	15.3	0	0.0	26.9	0	0.0

THEORETICAL TRANSMISSION SHIFT POINTS (TURBINE RPM), ENGINE AT FULL THROTTLE

1 > 2 :	2310	2 > 3 :	2290	3 > 4 :	2290
2 < 1 :	1150	3 < 2 :	1300	4 < 3 :	1300

Approval no. BDE 3
CLARK Components Europe

2 DEC 91 sheet 4 of 6
5T BOOM LIFT TRUCK

DRIVELINE DESCRIPTION

Engine : CAT 3116 296 HP at 2400 rpm
Transmission : 15.5LHR34414
Axle ratio : 9.250 Transfercase ratios : 1.900 0.900
Tire size : 20.5RX25 Rolling radius : 25.71 in (Static, loaded)

CALCULATED VEHICLE PERFORMANCE IN CONVERTER DRIVE

% Grade based on GTW, assuming 20/1000 rolling resistance, 10850.0 square in frontal area, air res. coeff: 0.000017 lbs per (MPH)squared per square in

transfercase ratio : 0.900

Pt	GEAR NO 1 RATIO = 5.325			GEAR NO 2 RATIO = 2.662			GEAR NO 3 RATIO = 1.515			GEAR NO 4 RATIO = 0.861		
no	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %
1	0.0	19089	69.5	0.0	9543	28.6	0.0	5431	15.0	0.0	3087	7.6
2	0.6	18636	67.0	1.2	9316	27.8	2.1	5302	14.6	3.7	3013	7.3
3	1.2	18094	64.1	2.4	9045	26.9	4.2	5148	14.1	7.4	2926	7.0
4	1.8	17481	61.0	3.5	8739	25.8	6.2	4973	13.5	11.0	2827	6.7
5	2.3	16828	57.8	4.7	8413	24.7	8.2	4788	12.9	14.4	2721	6.3
6	2.7	16372	55.7	5.4	8185	24.0	9.5	4658	12.5	16.7	2647	6.0
7	2.9	16088	54.4	5.8	8043	23.5	10.2	4577	12.2	17.9	2601	5.9
8	3.4	15162	50.2	6.9	7580	21.9	12.1	4314	11.3	21.2	2452	5.3
9	3.8	14490	47.4	7.5	7244	20.8	13.2	4123	10.7	23.2	2343	4.9
10	4.1	13755	44.4	8.2	6876	19.6	14.4	3913	10.0	25.4	2224	4.5
11	4.5	12921	41.0	9.0	6459	18.2	15.8	3676	9.3	27.8	2089	4.0
12	4.9	12084	37.8	9.9	6041	16.9	17.3	3438	8.5	30.5	1954	3.5
13	5.4	11236	34.7	10.8	5617	15.5	19.0	3197	7.7	33.5	1817	3.0
14	6.1	10043	30.4	12.2	5020	13.6	21.5	2857	6.6	37.9	1624	2.2
15	7.8	7916	23.0	15.5	3957	10.2	27.3	2252	4.5	48.1	1280	0.6
GOV>	7.9	7788	22.6	15.8	3893	9.9	27.7	2216	4.4	48.8	1259	0.5
16	8.4	3865	10.0	16.8	1932	3.8	29.6	1100	0.9	52.1	625	0.0
17	9.2	0	0.0	18.4	0	0.0	32.3	0	0.0	56.8	0	0.0

THEORETICAL TRANSMISSION SHIFT POINTS (TURBINE RPM), ENGINE AT FULL THROTTLE

1 > 2 : 2310	2 > 3 : 2290	3 > 4 : 2290
2 < 1 : 1150	3 < 2 : 1300	4 < 3 : 1300

Approval no. BDE 3
CLARK Components Europe

2 DEC 91 sheet 5 of 6
ST BOOM LIFT TRUCK

DRIVELINE DESCRIPTION

Engine : CAT 3116 296 HP at 2400 rpm
Transmission : 15.5LHR34414
Axle ratio : 9.250 Transfercase ratios : 1.900 0.900
Tire size : 20.5RX25 Rolling radius : 25.71 in (Static, loaded)

CALCULATED VEHICLE PERFORMANCE IN LOCKUP

% Grade based on GTW, assuming 20/1000 rolling resistance, 10850.0 square in frontal area, air res. coeff: 0.000017 lbs per (MPH)squared per square in

transfercase ratio : 1.900

	GEAR NO 1 RATIO = 5.325			GEAR NO 2 RATIO = 2.662			GEAR NO 3 RATIO = 1.515			GEAR NO 4 RATIO = 0.861		
Turb RPM	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %
1500	2.5	22933	95.2	4.9	11464	35.5	8.6	6525	18.4	15.2	3708	9.4
1680	2.7	22353	90.6	5.5	11174	34.4	9.7	6360	17.9	17.0	3614	9.0
1860	3.0	21475	84.2	6.1	10736	32.8	10.7	6110	17.1	18.8	3472	8.6
2040	3.3	20348	76.9	6.7	10172	30.8	11.7	5789	16.0	20.6	3290	8.0
2220	3.6	19183	70.0	7.3	9590	28.8	12.8	5458	15.0	22.5	3102	7.3
2400	3.9	18067	64.0	7.9	9032	26.8	13.8	5140	13.9	24.3	2921	6.7
2448	4.0	16385	55.7	8.0	8191	24.0	14.1	4662	12.4	24.8	2649	5.8
2496	4.1	12867	40.8	8.2	6432	18.2	14.4	3661	9.2	25.3	2081	4.1
2544	4.2	8533	25.1	8.3	4266	11.2	14.6	2428	5.4	25.7	1380	1.9
2592	4.2	3384	8.5	8.5	1692	3.2	14.9	963	0.8	26.2	547	0.0
2640	4.3	-2581	0.0	8.6	-1290	0.0	15.2	-734	0.0	26.7	-417	0.0

	GROSS TRAIN WT	EMPTY VEHICLE		Max speed in
Gear no 1 =	4.28 mph	4.28 mph	*	
Gear no 2 =	8.54 mph	8.54 mph	*	
Gear no 3 =	14.95 mph	14.95 mph	*	
Gear no 4 =	26.10 mph	26.10 mph	*	

Lock-up to be engaged and disengaged at 1669 turbine RPM when engine is at full throttle.

Approval no. BDE 3
CLARK Components Europe

5T BOOM LIFT TRUCK

DRIVELINE DESCRIPTION

Engine : CAT 3116 296 HP at 2400 rpm
Transmission : 15.5LHR34414
Axle ratio : 9.250 Transfercase ratios : 1.900 0.900
Tire size : 20.5RX25 Rolling radius : 25.71 in (Static, loaded)

CALCULATED VEHICLE PERFORMANCE IN LOCKUP

% Grade based on GTW, assuming 20/1000 rolling resistance, 10850.0 square in frontal area, air res. coeff: 0.000017 lbs per (MPH)squared per square in

transfercase ratio : 0.900

	GEAR NO 1 RATIO = 5.325			GEAR NO 2 RATIO = 2.662			GEAR NO 3 RATIO = 1.515			GEAR NO 4 RATIO = 0.861		
Turb RPM	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %	SPEED mph	T.E. lbs	GRADE %
1500	5.2	10863	33.3	10.4	5430	14.9	18.2	3091	7.4	32.0	1756	2.8
1680	5.8	10588	32.3	11.6	5293	14.4	20.4	3012	7.1	35.9	1712	2.5
1860	6.4	10173	30.8	12.9	5085	13.8	22.6	2894	6.7	39.7	1645	2.2
2040	7.0	9639	28.9	14.1	4818	12.9	24.8	2742	6.1	43.6	1558	1.7
2220	7.7	9087	27.0	15.3	4543	12.0	27.0	2585	5.6	47.4	1469	1.2
2400	8.3	8558	25.2	16.6	4278	11.1	29.1	2435	5.0	51.3	1384	0.7
2448	8.5	7761	22.5	16.9	3880	9.9	29.7	2208	4.3	52.3	1255	0.3
2496	8.6	6095	17.1	17.2	3047	7.3	30.3	1734	2.8	53.3	986	0.0
2544	8.8	4042	10.5	17.6	2021	4.1	30.9	1150	1.0	54.3	654	0.0
2592	9.0	1603	2.9	17.9	801	0.3	31.5	456	0.0	55.4	259	0.0
2640	9.1	-1223	0.0	18.2	-611	0.0	32.1	-348	0.0	56.4	-198	0.0

	GROSS TRAIN WT	EMPTY VEHICLE		Max speed in
Gear no 1 =	9.01 mph	9.01 mph	*	
Gear no 2 =	17.93 mph	17.93 mph	*	
Gear no 3 =	31.17 mph	31.17 mph	*	
Gear no 4 =	52.66 mph	52.66 mph	*	

Lock-up to be engaged and disengaged at 1669 turbine RPM when engine is at full throttle.

SCAAN No 323447 **Table 6.2.2.2.1**

date: 10/31/91, 12:47pm CET

tm887768, Eyre

ALLISON TRANSMISSION DIV

SCAAN Summary

Vehicle	MOBILE EQUIP- ROUGH TERRAIN -U. S. INDUSTRIES ATLAS 4X4
Engine	CAT 3116 ATAACM 250 CY91,CY90,TH2079 (Clutch fan ENGAGED)
Transmission	ALLISON MD3070PT (2-7)
Converter	ALLISON TC-417 REF. TC-19135, 10-3-90

	recommendation or rating	application	status
ENGINE:			
--->ENGINE RATING/VOCATION COMPATIBILITY			<-------
---> SUBJECT TO ENGINE MFGRS. REVIEW			<-------
CONVERTER:			
Stall turbine torque, lb.ft.	1350.max	1235.	O.K.
Engine rpm, conv. stall	(----)	1758.	
Converter stall torque ratio	(----)	2.160	
Eng peak torque rpm vs min. rpm	1533./100.min	1754.	O.K.
Conv. SR at 2600. gov rpm	0.800/1.000	0.937	O.K.
TRANSMISSION:			
Input horsepower	250.max	225.	O.K.
Input torque, lb.ft. (lockup)	700.max	616.	O.K.
Input rpm (gov.)	2000./2800.	2600.	O.K.
Transm output rpm, range 7 l.u. at 2600. rpm engine gov. speed	(----)	3321.	
VEHICLE/DRIVELINE:			
Vehicle GVW, lbs.	(----)	42000.	
1st conv stall tr.eff/veh.wt ratio	0.4000 min	0.8170	O.K.
Driveline reduction ratio	7.958min	10.102	O.K.
(reverse range, 70% conv. eff. at 0.400 traction coeff.)			
1st gear conv. stall gradeability	(----)	131.85%	
1st conv. 70% eff. gradeability	(----)	69.93%	
1st conv. 80% eff. gradeability	(----)	57.57%	
1st conv. 70% eff. transm BTU/min (at 1873. eng rpm)		3117.	
1st conv. 80% eff. transm BTU/min (at 1939. eng rpm)		2338.	
Geared mph @ gov rpm, range 7 l.u.	(----)	50.62	
max mph on 0.25% grade (clutch fan DISENGAGED) at 2553. engine rpm, range 7 l.u.	20.00min	49.11	O.K.

ALL TRANSMISSION APPLICATIONS require submittal to PRODUCT ENGINEERING DEPARTMENT

SCAAN No 323447
date: 10/31/91, 12:47pm CET
tm887768, Eyre

ALLISON TRANSMISSION DIV
Vehicle Full Throttle Performance
Clutch Fan Engaged

Reverse 1, ratio= -6.032 -start, converter operation

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min	
0.00	1758	29362	28522	0.0	92.51	8480	
-2.00	1870	21439	20599	114.3	56.28	3249	
-2.03	1873	21330	20486	115.3	55.87	32[illegible]	70% Conv. Efficiency
-2.70	1939	18650	17812	134.1	46.83	2449	80% Conv. Efficiency
-4.00	2101	14242	13400	151.9	33.66	1883	
-4.94	2260	11516	10673	151.7	26.27	2087	
-6.00	2572	10038	9193	160.6	22.43	172[illegible]	
-6.08	2600	9902	9057	160.6	22.08	1704	
-6.91	2792	841	-4	15.5	-0.01	721	

Forward 1, ratio= 6.929 -low range start, converter operation

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min	
0.00	1758	34305*	33465	0.0	131.85	8480	
1.76	1873	24910	24069	117.2	69.93	3117	70% Conv. Efficiency
2.00	1899	23628	22788	126.0	64.59	2752	
2.35	1939	21800	20956	136.4	57.57	2337	80% Conv. Efficiency
4.00	2194	14580	13738	155.5	34.61	1832	
4.30	2260	13517	12674	155.0	31.65	1927	
5.30	2600	11632	10788	164.3	26.58	1527	

Forward 2, ratio= 4.185 -drive range start, converter operation

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min	
0.00	1758	20871	20031	0.0	54.26	8480	
2.00	1819	17216	16376	91.8	42.34	4207	
2.92	1873	15100	14254	117.6	36.08	3098	70% Conv. Efficiency
3.89	1939	13180	12341	136.7	30.74	2328	80% Conv. Efficiency
4.00	1947	12965	12123	138.3	30.15	2266	
6.00	2124	9688	8843	155.0	21.54	1767	
7.12	2260	8063	7216	153.1	17.44	2020	
8.00	2418	7501	6652	160.0	16.04	1776	
8.77	2600	6902	6051	161.4	14.56	1667	

Forward 3, ratio= 2.237 -auto upshift, converter operation

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min
8.77	2002	6285	5434	146.9	13.05	1952
10.00	2061	5713	4859	152.4	11.65	1797
11.15	2120	5241	4384	155.8	10.49	1723
auto lockup shift						
11.15	1655	5241	4384	155.8	10.49	606
12.00	1782	5096	4236	163.1	10.14	651
14.00	2079	4676	3808	174.6	9.10	751
16.00	2376	4202	3326	179.3	7.94	828
17.51	2600	3809	2926	177.8	6.98	869

Forward 4, ratio= 1.691 -auto upshift, auto lockup shift

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min
17.51	1965	3664	2780	171.0	6.63	716

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veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min
18.00	2021	3598	2712	172.7	6.47	739
20.00	2245	3330	2433	177.6	5.80	818
22.00	2470	3045	2136	178.6	5.09	879
23.16	2600	2868	1952	177.1	4.65	904
Forward 5, ratio= 1.200 -auto upshift, auto lockup shift						
23.16	1845	2669	1753	164.8	4.18	738
24.00	1912	2618	1696	167.5	4.04	771
26.00	2071	2485	1548	172.3	3.69	850
28.00	2231	2344	1393	175.0	3.32	927
30.00	2390	2197	1229	175.7	2.93	1006
32.00	2549	2038	1053	173.9	2.51	1087
32.64	2600	1985	994	172.8	2.37	1113
Forward 6, ratio= 0.900 -auto upshift, auto lockup shift						
32.64	1950	1878	887	163.5	2.11	1051
34.00	2031	1825	821	165.5	1.95	1109
36.00	2150	1748	72[illegible]	167.8	1.72	1183
38.00	2270	1669	624	169.1	1.49	1251
40.00	2389	1589	521	169.5	1.24	1311
42.00	2509	1505	414	168.5	0.99	1362
43.53	2600	1439	330	167.0	0.78	1394
Forward 7, ratio= 0.783 -auto upshift, auto lockup shift						
43.53	2263	1386	276	160.8	0.66	1646
44.00	2287	1370	255	160.7	0.61	1673
46.00	2391	1301	160	159.6	0.38	1790
48.00	2495	1229	61	157.3	0.15	1911
50.00	2599	1153	-41	153.8	-0.10	2037
50.02	2600	1152	-42	153.7	-0.10	2038

Note: * exceeds vehicle traction limit

SCAAN No: 223447
date: 10/31/91, 12:47pm CET
tm887768, Eyre

ALLISON TRANSMISSION DIV
Engine Converter Match
Clutch Fan Engaged

speed ratio	.engine.. rpm	torque	....turbine.. hp	rpm	torque	heat rej BTU/min	
0.0000	1758	597	0.0	0	[illegible]	8480	
0.1000	1754	598	39.4	175	[illegible]	6799	
0.2000	1776	595	75.1	355	[illegible]	5380	
0.3000	1817	589	106.5	545	[illegible]	4133	
0.4000	1857	584	131.2	743	[illegible]	3189	
0.4333	1873	581	138.5	812	[illegible]	2918	70 % eff
0.5000	1907	576	152.0	954	[illegible]	2431	
0.5568	1939	571	161.3	1080	[illegible]	2105	80 % eff
0.6000	1966	567	167.2	1179	[illegible]	1912	
0.7000	2043	554	177.9	1430	653	1601	
0.7500	2088	547	182.4	1566	611	1488	
0.8000	2140	538	184.8	1712	567	1462	
0.8500	2213	525	183.6	1881	[illegible]	1602	
0.8750	2260	517	183.9	1978	[illegible]	1635	coupling
0.9000	2325	505	188.9	2092	474	1473	
0.9250	2472	478	194.6	2286	447	1279	
0.9310	2536	465	195.0	2361	434	1243	
0.9368	2600	452	195.1	2436	[illegible]	1210	gov. rpm
0.9434	2616	418	181.7	2468	387	1121	
0.9500	2632	384	168.0	2500	353	1041	
0.9750	2714	216	94.5	2646	180	730	
0.9900	2785	77	26.7	2758	51	607	

Lockup Operation

eng speed	...turb... torque	hp	
1500	590	168.5	
1560	590	175.3	
1655	584	184.1	conv-lockup [illegible]
1700	578	187.2	
1800	566	194.0	
2000	536	204.0	
2200	502	210.7	
2400	466	212.8	
2600	426	210.9	gov. rpm
2600	426	[illegible]	
2665	289	146.6	
2730	158	82.2	
2795	33	17.6	

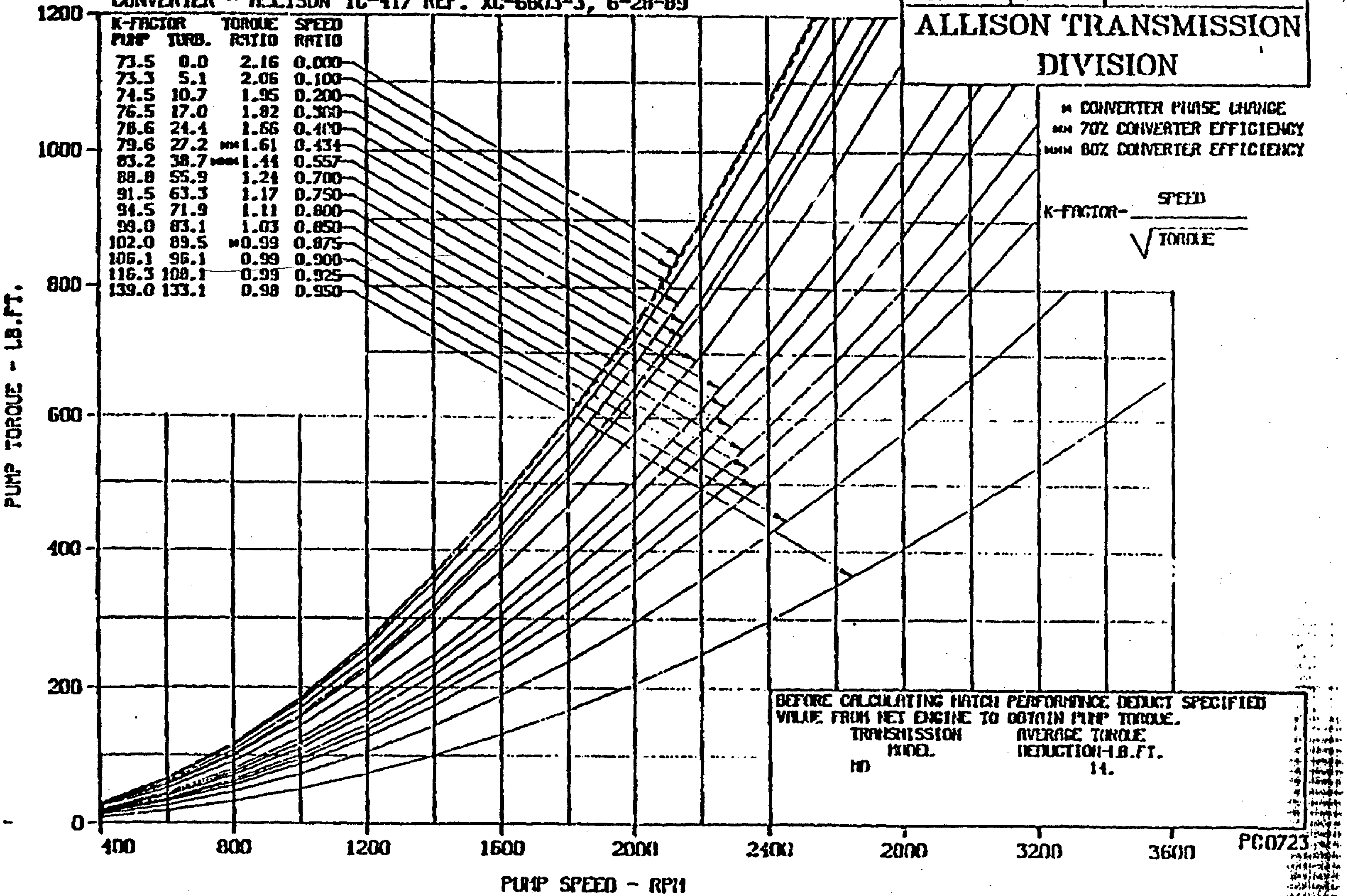
ENGINEER	DATE	TC-19135
LITTLE	10-3-90	

ALLISON TRANSMISSION DIVISION

ABSORPTION CHARACTERISTICS

CONVERTER - ALLISON TC-417 REF. XC-6603-3, 6-28-89

K-FACTOR PUMP	K-FACTOR TURB.	TORQUE RATIO	SPEED RATIO
73.5	0.0	2.16	0.000
73.3	5.1	2.06	0.100
74.5	10.7	1.95	0.200
76.5	17.0	1.82	0.300
78.6	24.4	1.66	0.400
79.6	27.2	** 1.61	0.434
83.2	38.7	*** 1.44	0.557
88.8	55.9	1.24	0.700
91.5	63.3	1.17	0.750
94.5	71.9	1.11	0.800
99.0	83.1	1.03	0.850
102.0	89.5	* 0.99	0.875
106.1	96.1	0.99	0.900
116.3	108.1	0.99	0.925
139.0	133.1	0.98	0.950



* CONVERTER PHASE CHANGE
** 70% CONVERTER EFFICIENCY
*** 80% CONVERTER EFFICIENCY

$$\text{K-FACTOR} = \frac{\text{SPEED}}{\sqrt{\text{TORQUE}}}$$

BEFORE CALCULATING MATCH PERFORMANCE DEDUCT SPECIFIED VALUE FROM NET ENGINE TO OBTAIN PUMP TORQUE.

TRANSMISSION MODEL	AVERAGE TORQUE REDUCTION-LB.FT.
MD	14.

PC0723

SCAAN No 326080
date: 11/28/91, 10:50am GMT
tm992012, ATD UNITED KINGDOM

ALLISON TRANSMISSION DIV
SCAAN Application Information

```
VEHICLE:  MOBILE EQUIP- ROUGH TERRAIN -D. J. INDUSTRIES ATLAS 4X4
     5600  vocation library file number
   42000.  lbs. gross vehicle weight
   42000.  lbs. weight on drive wheels (100.0 percent)
   25.575 in. radius, wheel-
   394.29 wheel rev/mile
   10.106 total driveline reduction ratio (transm. output to
           wheels) req'd for 50.00 mph geared top speed
          driveline: propeller shaft, wheel planetary, all wheel drv off hwy
    87.56 % driveline efficiency
    0.700 traction limit coefficient
     2.00 % rolling resistance
     70.0 sq.ft. vehicle frontal area
   0.8500 air resistance coefficient
 DIESEL ENGINE:  CAT 3116 300 HP
  (engine data responsibility: ATDUK)
   NOTE:  ENGINE RATING/VOCATION COMPATIBILITY
   SUBJECT TO ENGINE MFGRS. REVIEW.
   PERFORMANCE BASED ON PUBLISHED 'LUG-BACK' ENGINE DATA. ENGINE 'ACCEL'
   CHARACTERISTICS MAY INFLUENCE PERFORMANCE AS OUTLINED IN TD115.
    403.0 in3 engine displacement
  995674   engine library file number
   299.5  gross horsepower at 2600. rpm
  deductions- (hp. at 2600. rpm)
    19.5  hp fan (clutch engaged)
     0.0  hp fan (clutch disengaged)
     1.5  hp alternator/generator
     1.5  hp air compressor
     3.0  hp steer pump
     6.0  hp implement drive
   268.0 net horsepower    2600. rpm
    eng rpm      1400. 1500. 1600. 1800. 2000. 2200. 2400. 2600. 2850.
    entered hp  193 3 208.5 221.2 246.8 268.5 278.6 294.7 299.5   0.0
    net hp       183.1 197.2 208.7 231.5 250.0 256.4 268.2 268.0 -38.7
    net torque  686.7 690.4 684.9 675.5 656.5 612.0 586.9 541.4 -71.3
 (max. net   engine torque of  690.5 lb ft occurs at 1490. rpm)
 (max. gross engine torque of  730.0 lb ft occurs at 1506. rpm)
   0.932 lb.ft.sec.2 engine inertia
CONVERTER: ALLISON TC-419 REF. TC-19137, 10-3-90
TRANSMISSION: ALLISON MD3070PT (2-7)
   8589. lb.ft.   max transm output torque, 1st range conv stall
   7351. lb.ft.   max transm output torque, rev range conv stall
TRANSM. APPLICATION- MD3070PT (2-7) GENERAL
  16625     transm application library file number
```

THIS SCAAN INFORMATION SUBJECT TO
THE DISCLAIMER SET FORTH IN THE SCAAN USER'S MANUAL

SCAAN No 326080
date: 11/28/91, 10:50am GMT
tm992012, ATD UNITED KINGDOM

ALLISON TRANSMISSION DIV
SCAAN Summary

Vehicle	MOBILE EQUIP- ROUGH TERRAIN -D. J. INDUSTRIES ATLAS 4X4
Engine	CAT 3116 300 HP (Clutch fan ENGAGED) (engine data responsibility: ATDUK)
Transmission	ALLISON MD3070PT (2-7)
Converter	ALLISON TC-419 REF. TC-19137, 10-3-90

	recommendation or rating	application	status
ENGINE:			
--->ENGINE RATING/VOCATION COMPATIBILITY			<-------
---> SUBJECT TO ENGINE MFGRS. REVIEW			<-------
CONVERTER:			
Stall turbine torque, lb.ft.	1350.max	1283.	O.K.
Engine rpm, conv. stall	(----)	1693.	
Converter stall torque ratio	(----)	1.960	
Eng peak torque rpm vs min. rpm	1490.+100.min	1693.	O.K.
Conv. SR at 2600. gov rpm	0.800/1.000	0.938	O.K.
TRANSMISSION:			
--->Input horsepower	250.max	270.	<-(XXX)
Input torque, lb.ft. (lockup)	700.max	690.	O.K.
Input rpm (gov.)	2000./2800.	2600.	O.K.
Transm output rpm, range 7 l.u. at 2600. rpm engine gov. speed	(----)	3321.	
VEHICLE/DRIVELINE:			
Vehicle GVW, lbs.	(----)	42000.	
1st conv stall tr.eff/veh.wt ratio	0.4000 min	0.8490	O.K.
Driveline reduction ratio	7.291min	10.106	O.K.
(reverse range, 70% conv. eff. at 0.400 traction coeff.)			
1st gear conv. stall gradeability	(----)	148.27%	
1st conv. 70% eff. gradeability	(----)	90.63%	
1st conv. 80% eff. gradeability	(----)	67.31%	
1st conv. 70% eff. transm BTU/min (at 1876. eng rpm)		3553.	
1st conv. 80% eff. transm BTU/min (at 1966. eng rpm)		2703.	
Geared mph @ gov rpm, range 7 l.u.	(----)	50.00	
max mph on 0.25% grade (clutch fan DISENGAGED) at 2630. engine rpm, range 7 l.u.	20.00min	50.58	O.K.

ALL TRANSMISSION APPLICATIONS require submittal to PRODUCT ENGINEERING DEPARTMENT

NOTE: Symbols indicate:
--->Not within TRANSMISSION RATINGS <-(XXX)

SCAAN No 326080
date: 11/28/91, 10:50am GMT
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ALLISON TRANSMISSION DIV
Vehicle Full Throttle Performance
Clutch Fan Engaged

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min	
Reverse 1, ratio= -6.032 -start, converter operation							
0.00	1693	[illegible]523*	29683	0.0	99.89	9304	
-2.00	1857	[illegible]73	23032	127.3	65.58	3899	
-2.15	1876	[illegible]	22447	133.8	63.23	3663	70% Conv. Efficiency
-2.85	1966	20790	19946	157.9	53.96	2836	80% Conv. Efficiency
-4.00	2128	16706	15864	178.2	40.77	2212	
-5.25	2346	13255	12411	185.7	30.93	2217	
-6.00	2571	12187	11341	195.0	28.05	1959	
-6.09	2600	12017	11171	195.0	27.59	1920	
-6.92	2790	847	0	15.6	0.00	738	
Forward 1, ratio= 6.929 -low range start, converter operation							
0.00	1693	35661*	34821	0.0	148.27	9304	
1.88	1876	27200	26362	136.1	80.63	3553	70% Conv. Efficiency
2.00	1894	26595	25754	141.8	77.63	3343	
2.48	1966	24290	23452	160.7	67.31	2703	80% Conv. Efficiency
4.00	2217	17350	16508	185.1	42.74	1941	
4.57	2346	15552	14709	189.7	37.39	2025	
5.30	2600	14103	13259	199.2	33.27	1716	
Forward 2, ratio= 4.185 -drive range start, converter operation							
0.00	1693	21697	2085	0.0	57.21	9304	
2.00	1778	18722	1788[illegible]	99.8	47.05	4876	
3.11	1876	16490	15647	136.6	40.15	3529	70% Conv. Efficiency
4.00	1956	14886	14044	158.8	35.48	2758	
4.11	1966	14700	13857	161.0	34.95	2688	80% Conv. Efficiency
6.00	2151	11393	10548	182.3	25.95	2031	
7.57	2346	9292	8444	187.6	20.52	2123	
8.00	2426	9104	8255	194.2	20.04	1998	
8.77	2600	8406	7555	196.7	18.29	1841	
Forward 3, ratio= 2.237 -auto upshift, converter operation							
8.77	2022	7320	6469	171.2	15.57	2365	
10.00	2090	6718	5864	179.1	14.[illegible]	2118	
11.80	2181	5855	4996	184.3	11.98	1945	
auto lockup shift							
11.80	1754	5855	4996	184.3	11.98	667	
12.00	1783	5843	4983	187.0	11.95	679	
14.00	2080	5526	4658	206.3	11.16	788	
16.00	2377	5048	4172	215.4	9.98	870	
17.50	2600	4625	3741	215.8	8.94	913	
Forward 4, ratio= 1.691 -auto upshift, auto lockup shift							
17.50	1965	4307	3424	201.0	8.18	747	

SCAAN No 326080

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min
18.00	[illegible]	4232	3366	204.1	[illegible]	773
20.00	[illegible]	3915	3010	[illegible]	[illegible]	851
22.00	2471	3701	2792	217.1	[illegible]	919
23.15	2600	3485	2569	[illegible]	[illegible]	944
Forward 5, ratio= 1.200 -auto upshift, auto lockup shift						
23.15	1845	3095	2179	191.1	5.20	757
24.00	1913	3063	2141	196.0	5.10	792
26.00	2072	2946	2010	204.2	4.79	874
28.00	2231	2760	1809	206.1	4.31	951
30.00	2391	2661	1693	212.9	4.03	1034
32.00	2550	2493	1508	212.8	3.59	1116
32.63	2600	2426	1435	211.1	3.42	1142
Forward 6, ratio= 0.900 -auto upshift, auto lockup shift						
32.63	1950	2217	1225	192.9	2.92	1084
34.00	2032	2172	1168	196.9	2.78	1145
36.00	2151	2074	1049	199.1	2.50	1219
38.00	2271	1983	937	200.9	2.23	1287
40.00	2390	1934	866	206.3	2.06	1353
42.00	2510	1850	759	207.2	1.81	1406
43.51	2600	1767	658	205.0	1.57	1437
Forward 7, ratio= 0.783 -auto upshift, auto lockup shift						
43.51	2263	1658	549	192.4	1.31	1683
44.00	2283	1645	529	193.0	1.26	1712
46.00	2392	1601	461	196.4	1.10	1835
48.00	2496	1530	362	195.8	0.86	1958
50.00	2600	1437	242	191.7	0.58	2083
50.53	2628	1203	0	162.1	0.00	2082

Note: * exceeds vehicle traction limit

SCAAN No 326080 [illegible]

date: 11/28/91, 10:50am GMT
tm992012, ATD UNITED KINGDOM

ALLISON TRANSMISSION DIV
Engine Converter Match
Clutch Fan Engaged

speed ratio	.engine.. rpm	torque	....turbine.... hp	rpm	torque	heat rej BTU/min	
0.0000	1693	680	0.0	0	1283	9304	
0.1000	1693	680	40.1	169	1244	7603	
0.2000	1721	679	78.3	344	1196	6113	
0.3000	1770	677	113.2	531	1120	4873	
0.4000	1837	673	144.1	735	1031	3865	
0.4600	1876	669	160.8	863	979	3322	70 % eff
0.5000	1903	667	171.2	952	945	2987	
0.5805	1966	660	189.9	1141	874	2430	80 % eff
0.6000	1983	659	194.0	1190	857	2317	
0.6500	2026	652	202.3	1317	807	2091	
0.7000	2079	642	209.8	1455	757	1880	
0.7500	2126	632	214.6	1594	707	1741	
0.8000	2176	619	217.4	1741	656	1650	
0.8500	2248	604	220.4	1911	606	1622	
0.8970	2346	592	225.1	2104	562	1667	coupling
0.9250	2479	571	235.7	2293	540	1443	
0.9315	2540	556	236.3	2366	525	1389	
0.9377	2600	541	236.5	2438	509	1338	gov. rpm
0.9439	2613	508	223.5	2466	476	1237	
0.9500	2625	474	210.1	2494	442	1144	
0.9750	2708	264	118.0	2640	235	770	
0.9900	2773	105	41.0	2746	78	620	

Lockup Operation

eng speed	...turb... torque	hp	
1400	661	176.2	
1500	665	189.9	
1600	659	200.8	
1754	652	217.7	conv-lockup intersection
1800	650	222.7	
2000	631	240.2	
2200	586	245.6	
2400	561	256.5	
2600	516	255.3	gov. rpm
2600	516	255.3	
2663	352	178.4	
2725	196	101.5	
2788	46	24.5	

6.3 Performance.

The power train, required to meet the speed and torque requirements of ATLAS, substantially contributes to the weight growth of the ATLAS. The weight growth is within the additional weight required to accommodate the lift requirements.

Performance is not otherwise compromised by the application of the components of the powertrain.

6.4 HFE/Safety.

Implementation of the powertrain components are not projected to introduce HFE or safety concerns once the braking issues are addressed.

6.5 Reliability.

The power train reliability allocation (MTBF) is 1000 hours. The allocation is low given the uncertainty of the ratings assigned to each of the components.

6.6 Producibility.

Modification of most if not all of the commercial power train components is required to meet performance requirements. Modifications to meet fording and corrosion considerations are limited to providing vents/breathers and sealing of filler tubes/dipsticks.

6.7 Cost Impact.

With the modifications of commercial products the economies of scale are sacrificed. The most significant modifications are to the axles. Modifications may increase the cost of each axle by $1500. These modifications to the axle would involve increasing brake capacity and changing axle ratios to provide the required speed. Configuration changes to fulfill fording and corrosion requirements are trivial.

6.8 Integrated Logistic Support.

Reliability of the powertrain may be affected by the performance requirements of the ATLAS vehicle. The potential impact on reliability will need to be offset against the cost/weight/size/transportability concerns with maturation of the design. Most RAM-D considerations are discussed above, so will not be repeated. The maintainability requirements will increase for any design alternative. The increase in components will have a minor impact on provisioning costs. This system should have the most potential impact on ILS concerns within the ATLAS vehicle.

Paragraph 7.0
Hydraulic System

7.1 Baseline Description.

The baseline description establishes the hydraulic arrangement of the RT100 from which the alternative ATLAS designs evolve. The RT100 implements electric-over-hydraulic controls for boom movements, steering, raising/lowering outriggers, etc. This control eliminates mechanical linkages and hydraulic lines for increased reliability. The electro-hydraulic control system gives the operator smooth, precise control of the load to facilitate load engagement and placement. The electronic control box is environmentally sealed and design for off-road application. The heavy duty box is iso-mounted within the cab to reduce vibrational loading and provide redundant protection from the elements.

Solenoid-actuated main control valve spools are enclosed within the hydraulic control body to seal out dirt and moisture and eliminate leaks.

7.1.1 Pump-Hydraulic. Load sensing, variable displacement piston pump reduces engine loads and hydraulic oil temperature for increased reliability and durability. The pump varies its output to match constantly changing system requirements.

7.1.2 Cylinders-Hydraulic. Spherical bushing isolate hydraulic cylinders from off-center loads that would otherwise reduce cylinder and seal life. Chrome plated cylinder rods resist both wear and corrosion. Wiper seals prevent intrusion of particles that wear seals.

7.2 Alternative Design.

The hydraulic design of the ATLAS will be essentially unchanged from the commercial vehicle except that ATLAS may incorporate a hydro-pneumatic suspension (Paragraph 5.0), a sealed hydraulic tank, and bulkhead connectors through watertight compartment.

7.2.1 Connectors-Bulkhead. Each hydraulic hose that penetrates a compartment to be sealed will be replaced by two shorter hoses and a bulkhead connector. Bulkhead connectors will be used to penetrate a watertight structure.

7.2.2 Hydraulic Tank-Sealing. Alternative designs are identified in the Hydraulic System Contamination Study to eliminate the potential of NBC particles contaminating the hydraulic oil via the breather of the hydraulic tank.

7.3 Performance.

Implementation of a tailored hydraulic system will not compromise the performance of ATLAS.

7.4 HFE/Safety.

Implementation of a tailored hydraulic system will not compromise the HFE/Safety requirements of ATLAS.

7.5 Reliability.

Implementation of a tailored hydraulic system will not compromise the reliability of ATLAS.

7.5.1 Connectors-Bulkhead. The incremental increase in number of bulkhead connectors and hoses increase system complexity but still remain within the reliability allocation (MTBF=1000 hours).

7.5.2 Cylinders-Hydraulic. Reliability of the hydraulic cylinders is typically the primary source of unreliability as a result of oil leaks. Other than mechanical damage to the cylinder rod that damages the seals, most damage to the rod seals occurs due to the presence of a 3rd particle intrusion. The fording environment provides a number of sources of 3rd particles. Corrosion products, resulting in pitting of the rod, are generated as a result of inadequate plating thickness. 3rd particles, sand and debris, are suspended in the surf zone. Hydraulic cylinders suitable for sustained fording operations required a wiper seal to prevent the 3rd particles from coming into contact with the rod seals.

The cylinder rod can be protected from pitting and corrosion damage with a 0.016" chrome plating.

7.5.3 Hydraulic Tank. Replacing the breather of the hydraulic tank with a bladder may serve to eliminate a source of contamination and increase the life of the hydraulic pump.

7.6 Producibility.

The increase in number of hoses, bulkhead connectors, and associated assemblies serve to decrease the producibility of ATLAS. Replacing the breather on the hydraulic tank with an internal bladder will add minimum material cost and assembly effort.

7.7 Cost Impact.

The increase in number of hoses, bulkhead connectors, and associated assembly time will increase the cost of ATLAS by approximately $2500..

7.8 Integrated Logistic Support.

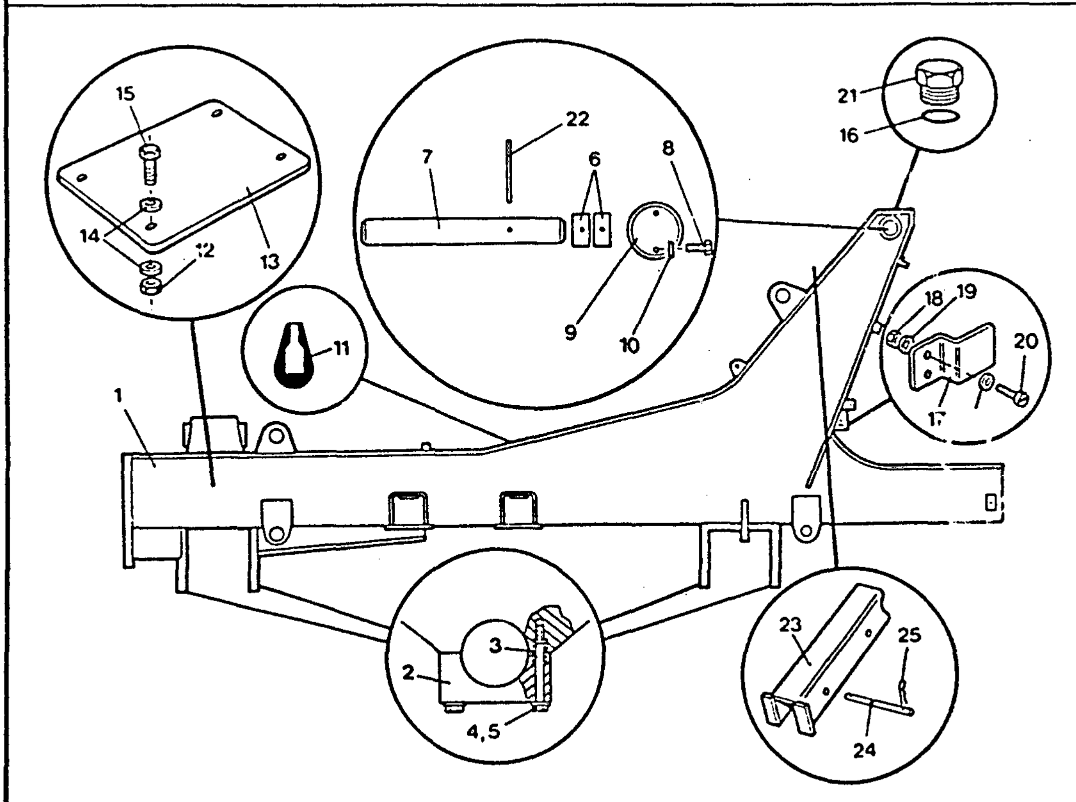
The minor modifications suggested for ATLAS should have very minor effects on reliability and availability. A minor improvement in maintainability may be seen through the use of bulkhead connectors and separated hydraulic lines. This will have only minor effects on provisioning.

Paragraph 8.0
Chassis

8.1 Baseline Description.

The baseline description establishes the chassis arrangement of the RT100 from which the alternative ATLAS designs evolve. The RT100 provides a strong stiff frame that resists distortion and fatigue cracking in tough applications. For purposes of this evaluation, the chassis group (Figure 8.1-1) includes the engine cowl and platform group (Figure 8.1-2) as well as the concept design for the carriage and A-frame required for the ATLAS suspension (Paragraph 5.0). The baseline vehicle implements a common one-piece, unitized main frame. The frame has box section side rails, which are joined by thick plate bulkheads for good torsional rigidity.

FRAME AND PANELS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	837945	1	CHASSIS FRAME AS.
NSS	2	------	4	KEEP
	3	8T1584	8	BUSHING
M	4	8T0650	8	BOLT
M	5	5P8247	8	WASHER
	6	897354	4	BUSH
	7	6R7899	1	PIVOT PIN
M	8	5C9553	4	BOLT
	9	815933	2	END COVER
M	10	8T4205	4	WASHER
D	11	816274	1.0	EDGING
M	12	6V7744	4	NUT - SELF LOCKING
	13	838781	1	TOP PLATE
M	14	8T4121	8	WASHER
M	15	8T4196	4	BOLT
	16	3K0360	2	O RING O.R.B.
	17	6R7946	2	PLATE CATCH
M	18	6V7743	4	NYLOC NUT
M	19	8T4205	8	WASHER
M	20	8T6412	4	SCREW
	21	9S4185	2	PLUG
	22	6R7924	1	ROLL PIN
	23	6R7486	2	CLAMP AS
	24	6R9007	4	PIN
	25	6V9197	8	R CLIP

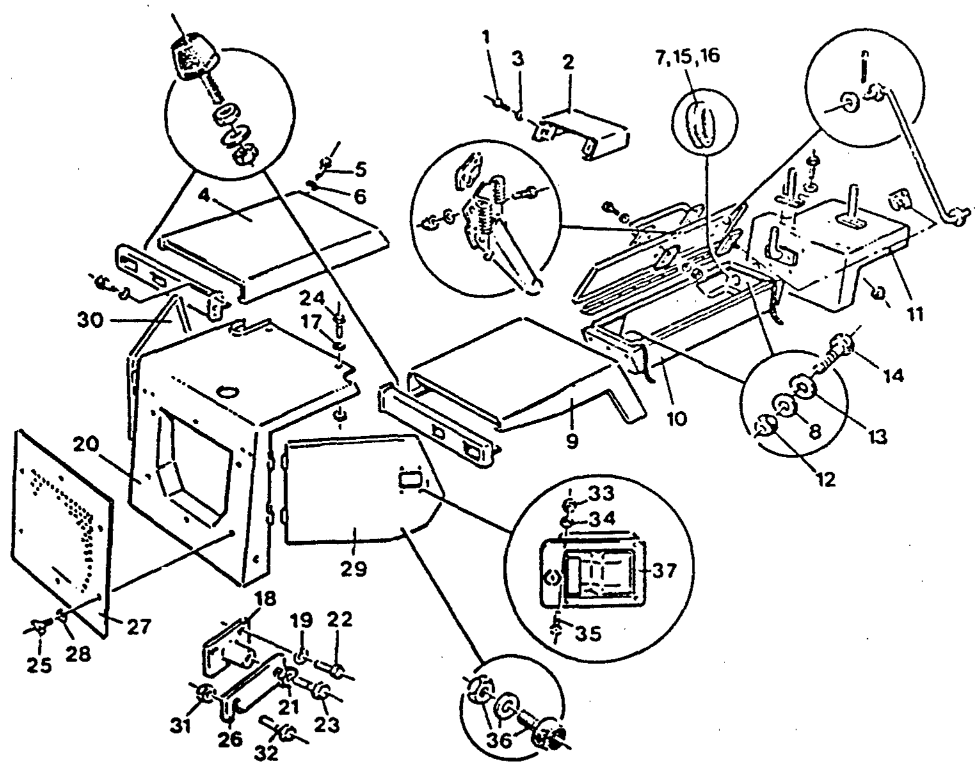
M - METRIC PART
D - ORDER BY THE METER
NSS - NOT SERVICED

P837967 Y
REV 004

837967 CHASSIS FRAME GROUP

Figure 8.1-1 Chassis Frame Group

FRAME AND PANELS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	7X2548	4	BOLT		20	838626	1	ENGINE COWL AS
	2	844131	1	FRONT DECKING AS	M	21	8T4133	2	NUT
M	3	8T4223	4	WASHER	M	22	8T4136	4	BOLT
	4	6R7592	1	REAR DECKING AS	M	23	8T4166	2	BOLT
M	5	7X2548	4	BOLT	M	24	8T4192	4	BOLT
M	6	8T4223	4	WASHER		25	6R7613	5	WING BOLT
	7	3H2900	2	GROMMET		26	6R7755	2	LATCH
M	8	5P4116	12	WASHER		27	6R9163	1	RADIATOR GRILLE
	9	6R9031	1	REAR WING AS	M	28	7X7729	6	WASHER
	10	6R9032	1	CENTRE WING AS		29	838635	1	COWL DOOR AS
	11	6R9033	1	FRONT WING AS.		30	838658	1	COWL DOOR AS
M	12	6V9189	24	NYLOC NUT	M	31	8T4133	2	NUT
M	13	897961	36	WASHER	M	32	8T4136	2	BOLT
M	14	8T4189	24	BOLT	M	33	6V7743	8	NYLOC NUT
	15	2U4578	2	GROMMET	M	34	8T4205	8	WASHER
	16	9D7303	1	GROMMET	M	35	8T6411	8	SCREW
M	17	5P1076	4	WASHER		36	985613	2	G M T BUFFER
	18	6R7753	2	CATCH AS. - COWL		37	9X2299	2	LATCH
M	19	6V5839	4	WASHER					

M - METRIC PART

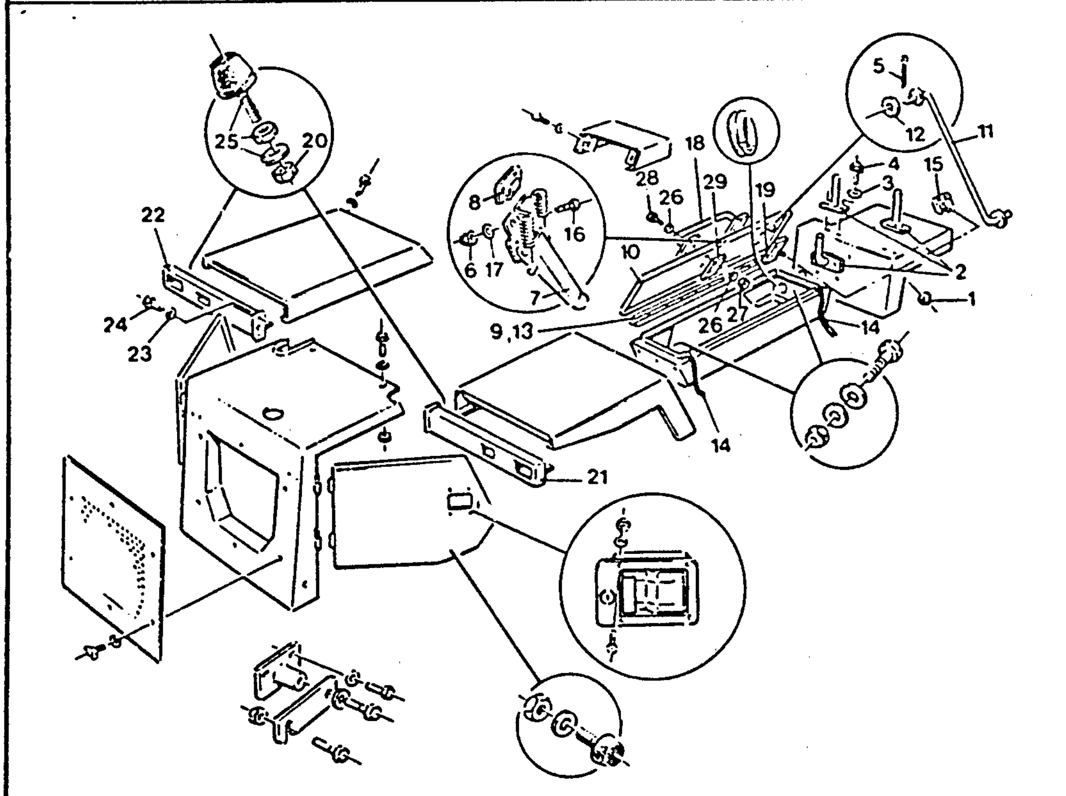
P6R7741 Y

REV 008

6R7741 ENGINE COWL AND PLATFORM GROUP (1 of 2)

Figure 8.1-2 Engine Cowl and Platform Group Part 1

FRAME AND PANELS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V7744	6	NUT - SELF LOCKING	M	17	8T0328	4	WASHER
NSSY	2	8O2077	1	MIRROR GROUP		18	8O2069	1	GRAB HANDLE
M	3	8T4121	6	WASHER		19	8O2074	1	PLATE AS.
M	4	8T4136	6	BOLT	M	20	5C2890	4	NUT
	5	3B4609	1	COTTER PIN		21	6R7589	1	BRACKET WELD AS. R.H.
M	6	3T0851	4	NUT- SELF LOCKING		22	6R7590	1	BRACKET WELD AS. L.H.
	7	3U2004	i	FASTENER	M	23	8T4121	4	WASHER
	8	5U5009	1	CATCH PLATE	M	24	8T4137	4	BOLT
	9	6R7680	1	HINGE CONTINUOUS		25	985613	4	G M.T.BUFFER
	10	6R9102	1	PLATFORM COVER AS.	M	26	6V5839	8	WASHER
	11	6R9111	1	STAY AS.- TANK LID	M	27	6V7744	4	NYLOC NUT
M	12	6V7699	1	WASHER	M	28	8T4137	4	BOLT
M	13	8O2078	20	RIVET	M	29	985250	1	PLATE
	14	815720	2	SEAL (0.86M LONG)					
	15	816087	1	PLASTIC CLIP					
M	16	8T0288	4	BOLT					

M METRIC PART
NSS NOT SERVICED
Y SEPARATE ILLUSTRATION

P6R7741 Y
REV C08

6R7741 ENGINE COWL AND PLATFORM GROUP (2 of 2)
8O2077 - PAGE 237

Figure 8.1-2 Engine Cowl and Platform Group Part 2

8.2 Alternative Design.

The chassis will be a new design to accommodate the front and rear suspensions group and the new powertrain components.

8.2.1 Corrosion. The chassis design will incorporate features to minimize the incidence of crevice corrosion. General corrosion resistance of these mild steel structures will be provided by the corrosion resistant primer.

8.2.2 Sound Suppression. Reduction of operator and spectator noise will require shrouding of the engine compartment. Typical materials, foams and fiberglass, used for sound suppression within an engine compartment will tend to retain moisture adjacent to the crowl or engine enclosure. This moisture will facilitate corrosion of the substrate if the corrosion resistance is not maintained. Alternative sound suppression methods can be pursued as required in later stages of ATLAS development.

8.3 Performance.

Implementation of the chassis group will not compromise the performance of ATLAS. The weight growth projected for the chassis group is accounted for within the projected weight of 32,500 lbs.

8.4 HFE/Safety.

Implementation of the chassis group will not compromise the HFE/Safety of ATLAS. Engineering changes to the chassis group to provide the necessary corrosion resistance will facilitate decontamination of the vehicle.

8.5 Reliability.

Implementation of the chassis group will not compromise the reliability of ATLAS. The reliability allocation assigned the chassis group (MTBF=10,000 hours) may be conservative given that the duty cycle of ATLAS is moderate when compared to commercial RTFLs.

8.6 Producibility.

Components of the chassis group will be redesigned to meet the fording and corrosion considerations. Box beam sections will be watertight. Intermittent welds will be replaced by continuous welds. Cup-like features that would other wise retain water, will include a provision for drainage. Holes will be plugged or other wise sealed.

8.7 Cost Impact.

Design changes to provide the desired corrosion resistance will have minimum impact on cost growth, i.e. less than $500.

8.8 Integrated Logistic Support.

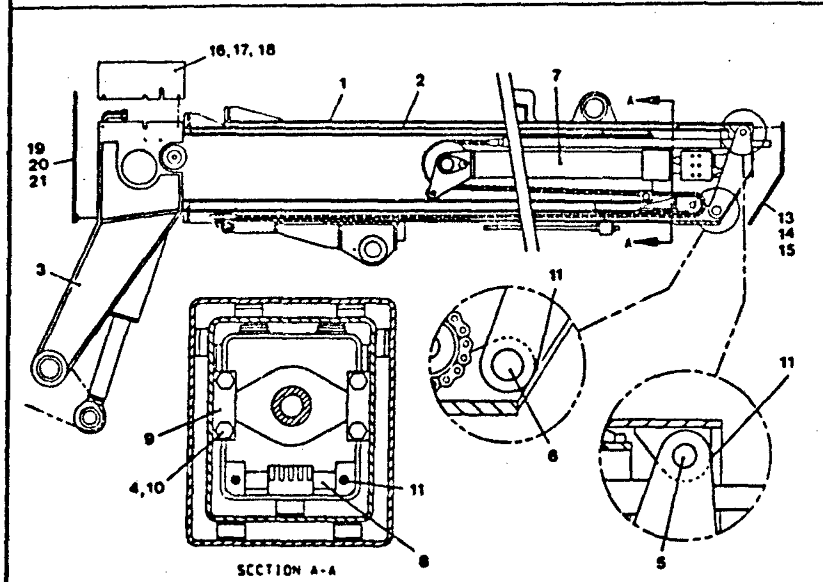
The reliability of the chassis group is excellent. Potential reliability problems created by ATLAS requirements can be addressed through vehicle chassis modifications. RAM-D considerations are minor for the corrosion resistive design planned for ATLAS. Design changes should have minor or no difference created for provisioning.

Paragraph 9.0
Boom and End Effecters

9.1 Baseline Description.

9.1.1 Boom-3 Piece. The RT100 provides a 3 pc boom assembly (Figure 9.1.1-1).

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
NSSY	1	985889	1	No 1 BOOM SECTION GP
NSSY	2	985979	1	No 2 BOOM SECTION GP
NSSY	3	986070	1	BOOM HEAD SECTION GP
M	4	6V3532	4	BOLT
	5	837989	1	TOP ANCHOR SHAFT
	6	837990	1	BOTTOM ANCHOR SHAFT
NSSY	7	837991	1	TELESCOPING GP
	8	897359	1	CHAIN ANCHOR SHAFT
	9	897367	2	KEEP PLATE
M	10	8T3282	4	WASHER
M	11	8TO351	6	SET SCREW
	13	837993	1	REAR COVER
M	14	8C8585	4	SCREW
M	15	8T4121	4	WASHER
	16	6R8922	1	COOM HEAD COVER
M	17	8T4121	4	WASHER
M	18	8T4137	4	BOLT
	19	837995	1	FRONT COVER
M	20	8T4137	6	SCREW
M	21	8T4121	6	WASHER
NSSY	F	844146	1	ELECTRICAL GROUP - BOOM
NSSY	F	838010	1	BOOM HYDRAULIC GROUP
NSSY	F	838524	1	QUICK HITCH GROUP
NSSY	F	838024	1	COMPENSATING GROUP

Y - SEPARATE ILLUSTRATION
F - NOT SHOWN
M - METRIC PART
NSS - NOT SERVICED
P985888 Y
REV00 S

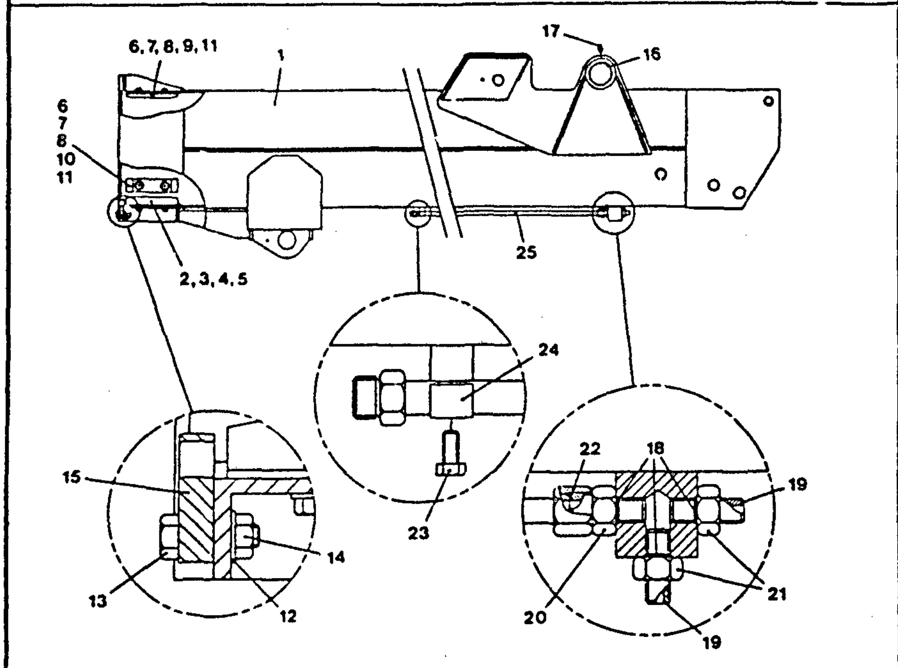
985888 3-SECTION BOOM GRP (WITH COMPENSATING CYLINDERS)

Figure 9.1.1-1 Boom Assembly

The boom assembly consists of:

No 1. Boom Section Group	*Figure 9.1.1-2*
No 2. Boom Section Group	*Figure 9.1.1-3*
Boom Section Head Assembly	*Figure 9.1.1-4*
Telescoping Group	*Figure 9.1.1-5*

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	985890	1	NO 1 BOOM SECTION AS	M	14	6V8149	2	NUT
M	2	897344	2	SHIM 5MM		15	897321	1	CHAIN BRACKET
M	3	8T4121	4	WASHER	M	16	897345	2	BUSH
M	4	8T4195	4	BOLT		17	3B8488	2	GREASE NIPPLE
Y	5	985845	2	WEAR PAD GP		18	3K0360	8	O RING
MB	6	897342	-	SHIM 0 75MM		19	6V8398	6	O RING
MB	7	897343	-	SHIM 1 5MM		20	6V8632	2	ADAPTOR
M	8	8T4121	8	WASHER		21	6V8639	6	ADAPTOR
M	9	8T4136	4	BOLT		22	7J9106	2	O RING
M	10	8T4196	4	BOLT	M	23	5C9553	2	BOLT
Y	11	985843	4	WEAR PAD GP		24	815943	2	PIPE CLIP
M	12	5P8245	2	WASHER		25	985977	2	STEEL PIPE AS
M	13	6V7673	2	BOLT	NSSY	F	815728	1	ROLLING HOSE GP

B - USE AS REQUIRED
M - METRIC PART

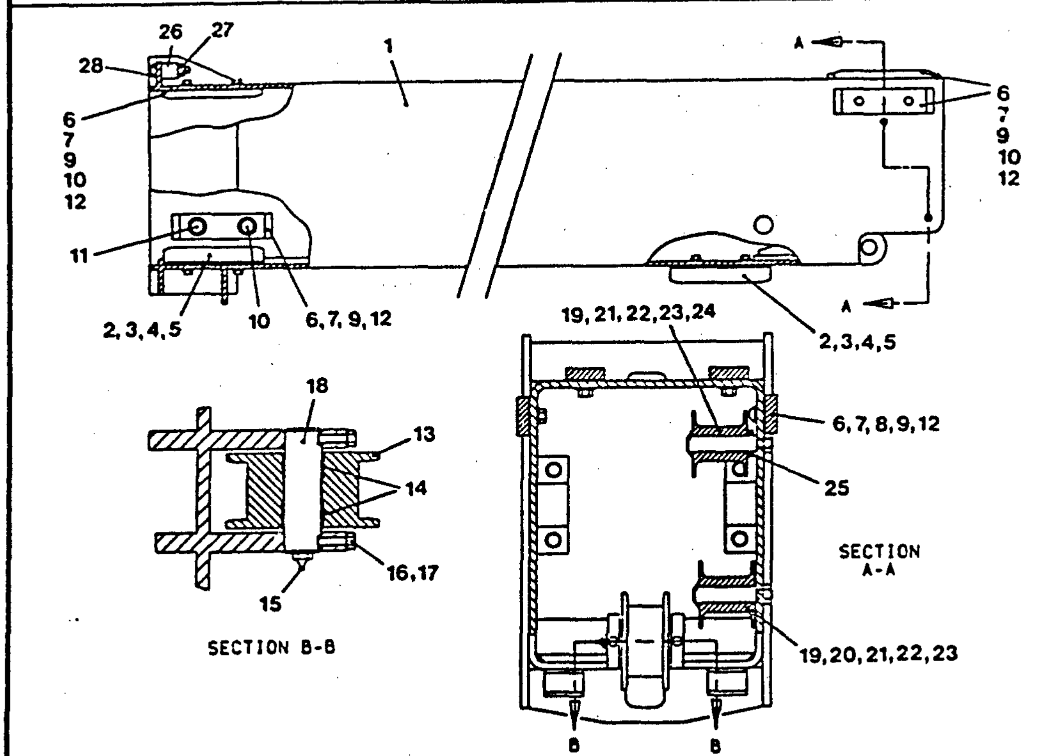
NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION
F - NOT SHOWN

P985889 Y
REV000

985889 No.1 BOOM SECTION GRP (WITH COMPENSATING CYLINDERS)
Part of 985888 Three Section Boom (with Compensating Cylinders)

Figure 9.1.1-2 No. 1 Boom Section Group

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	985980	1	NO.2 BOOM SECTION AS
M	2	897344	4	SHIM 5MM
M	3	8T4121	8	WASHER
M	4	8T4195	8	BOLT
Y	5	985845	4	WEAR PAD GP
MB	6	897342	-	SHIM 0.75MM
MB	7	897343	-	SHIM 1.5MM
M	8	6R9245	2	SCREW
M	9	8T4121	16	WASHER
M	10	8T4136	12	BOLT
M	11	8T4196	2	BOLT
Y	12	985843	8	WEAR PAD GP
	13	815738	1	CHAIN PULLEY

NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	14	897346	2	BUSH
	15	3B8489	1	GREASE NIPPLE
M	16	6V7357	2	BOLT
M	17	8T4205	2	WASHER
	18	986001	1	SHAFT
M	19	3B4624	2	SPLIT PIN
	20	838627	1	ROLLER PIN
M	21	897325	2	ROLLER PULLEY
M	22	8T4123	2	WASHER
	23	6V7687	2	NUT
	24	897326	1	ROLLER PIN
	25	908395	1	WASHER
A	26	816344	2	SPACER
AM	27	8T4133	2	NUT
AM	28	8T6466	2	BOLT

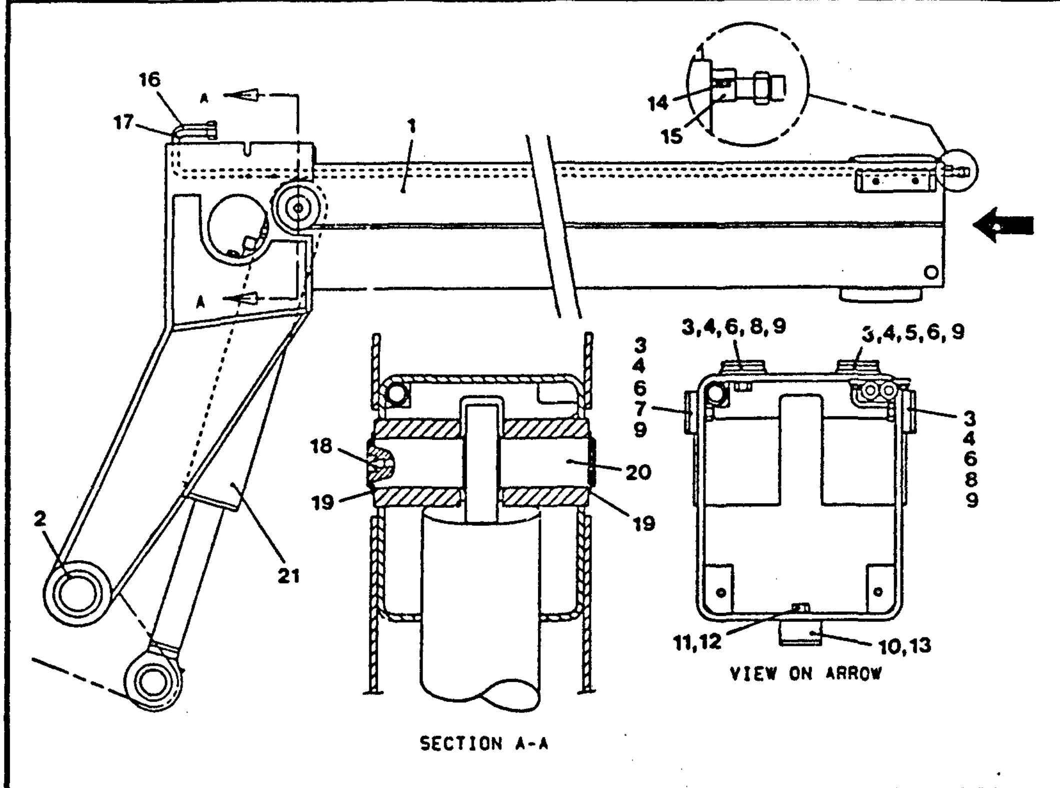
B - USE AS REQUIRED
M - METRIC PART
Y - SEPARATE ILLUSTRATION
A - NOT PART OF THIS GROUP

P985979 Y
REV002

985979 No.2 BOOM SECTION GROUP
Part of 985888 Three Section Boom (with Compensating Cylinders)

Figure 9.1.1-3 No. 2 Boom Section Group

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	986071	1	BOOM HEAD SECTION AS	M	12	8T4196	2	BOLT
M	2	897354	4	BUSH	Y	13	985845	1	WEAR PAD GP
MB	3	897342	-	SHIM 0.75MM	M	14	7X2619	2	BOLT
MB	4	897343	-	SHIM 1.5MM		15	815948	2	PIPE CLIP
M	5	897942	2	SCREW		16	837864	1	STEEL PIPE AS
M	6	8T4121	8	WASHER		17	837865	1	STEEL PIPE AS
M	7	8T4136	2	BOLT		18	3B8489	1	GREASE NIPPLE
M	8	8T4137	4	BOLT	M	19	5K4627	2	SNAP RING
Y	9	985843	4	WEAR PAD GP		20	837898	1	SHAFT
M	10	897344	1	SHIM 5MM	NSSY	21	837931	1	FORK LEVEL GP
M	11	8T4121	2	WASHER					

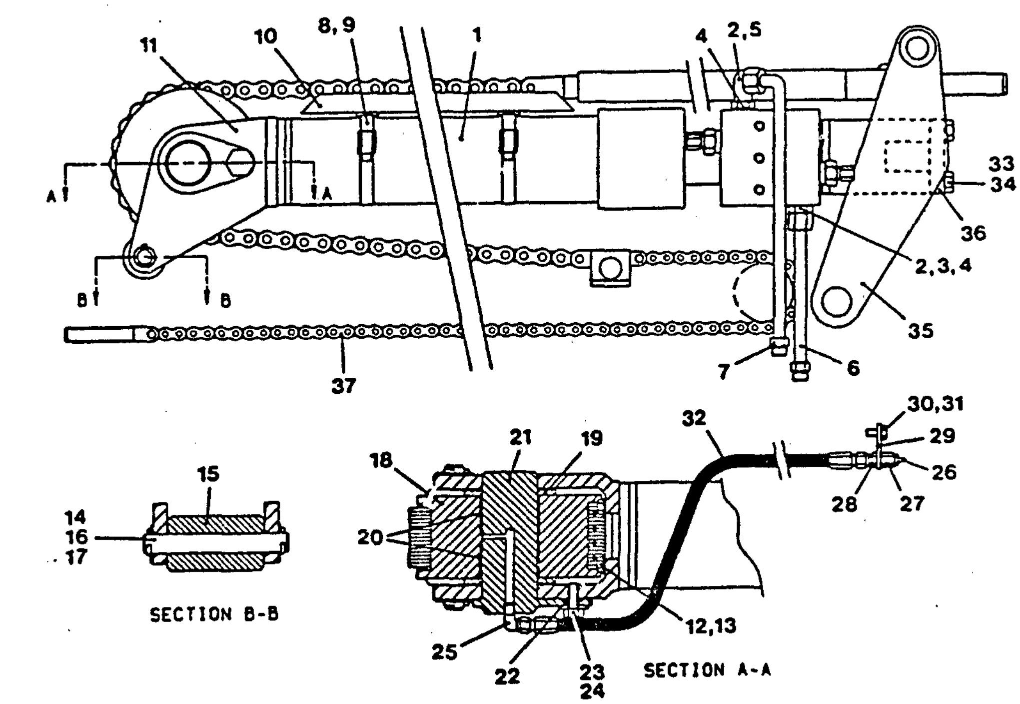
B - USE AS REQUIRED
NSS - NOT SERVICED
M - METRIC PART
Y - SEPARATE ILLUSTRATION

P986070 Y
REV000

986070 BOOM HEAD SECTION
Part of 985888 Three Section Boom (with Compensating Cylinders)

Figure 9.1.1-4 Boom Section Head Assembly

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	837992	1	TELESCOPING CYLINDER GP	M	20	897335	2	BUSH
	2	3D2824	2	O RING		21	897336	1	SHAFT
	3	6V8713	1	ADAPTOR		22	897338	1	SLEEVE
	4	7J9108	2	O RING	M	23	8T4136	1	BOLT
	5	8T0404	1	ELBOW	M	24	8T4222	1	WASHER
	6	986044	1	STEEL PIPE AS		25	2N1287	1	ELBOW
	7	986045	1	STEEL PIPE AS		26	3B8489	1	GREASE NIPPLE
	8	5P0599	5	HOSE CLAMP		27	4U1697	1	ADAPTOR
	9	815551	5	RUBBER STRIP		28	5B3254	1	NUT
	10	986038	1	CHAIN TRAY AS		29	816186	1	BRACKET
	11	815732	1	BRACKET AS	M	30	8T4200	1	BOLT
M	12	8T4224	4	WASHER	M	31	8T4224	1	WASHER
M	13	8T7547	4	BOLT		32	986043	1	PIPE AS
M	14	3B4624	2	SPLIT PIN	M	33	6V5685	4	BOLT
	15	897324	1	ROLLER	M	34	6V8765	4	WASHER
	16	897334	1	SHAFT		35	986032	1	CYLINDERANCHOR AS
M	17	8T3282	2	WASHER		36	986037	1	KEEP PLATE
	18	815733	1	CHAIN PULLEY	Y	37	986027	1	CHAIN GP
	19	815734	2	SPACER					

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P837991 Y
REV000

837991 TELESCOPING GROUP
Part of 985888 Three Section Boom Group (with Compensating Cylinders)

Figure 9.1.1-5 Telescoping Group

9.1.2 Capacity Charts. The capacity of the RTFLs vary with lift height and forward reach, and depends on which attachment is installed and whether the machine is equipped with optional outriggers. (Note that commercial capacity charts do not provide for the 24" load center required by US Army). The RTFLs have two-dimensional "capacity charts" to show the capacities of the machine throughout the boom range. Capacity charts for the following are provided:

Configuration		*Figure*
Fixed Carriage	*No Outriggers*	*9.1.2-1*
" "	*Outriggers Up*	*9.1.2-2*
" "	*Outriggers Down*	*9.1.2-3*
Tilt Carriage	*No Outriggers*	*9.1.2-4*
" "	*Outriggers Up*	*9.1.2-5*
" "	*Outriggers Down*	*9.1.2-6*
Truss Boom, No Outriggers and Outriggers Up or Down		*9.1.2-7*

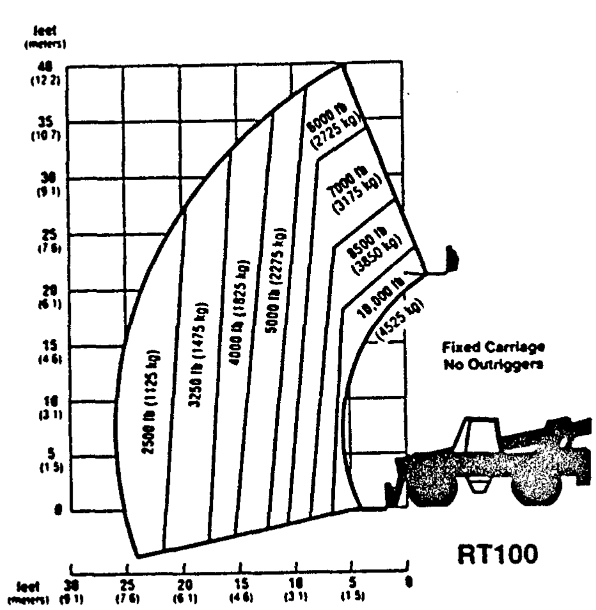


Figure 9.1.2-1 Fixed Carriage No Outriggers

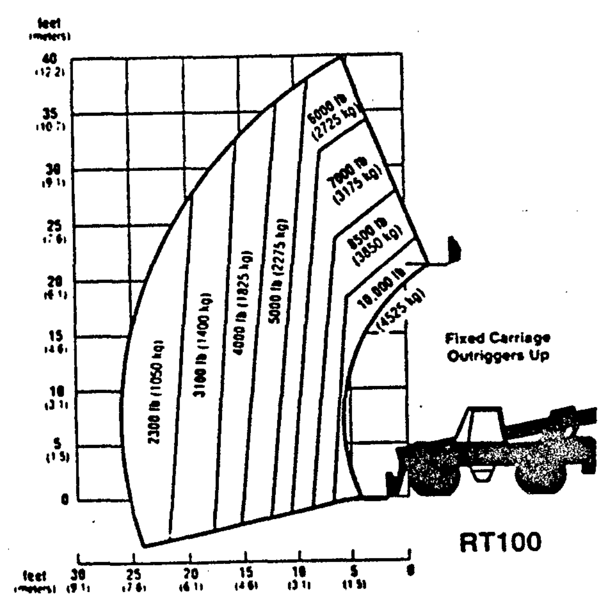


Figure 9.1.2-2 Fixed Carriage Outriggers Up

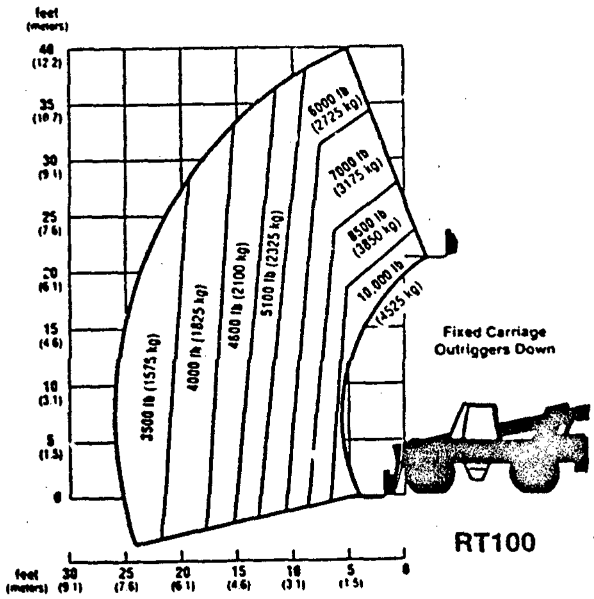


Figure 9.1.2-3 Fixed Carriage Outriggers Down

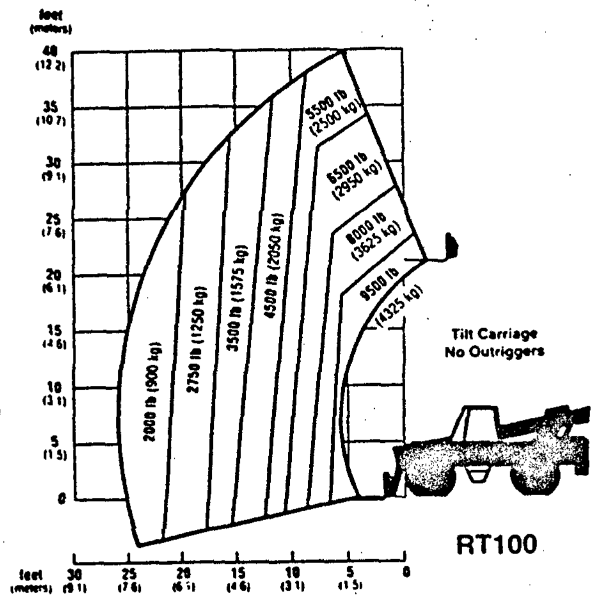


Figure 9.1.3-4 Tilt Carriage No Outriggers

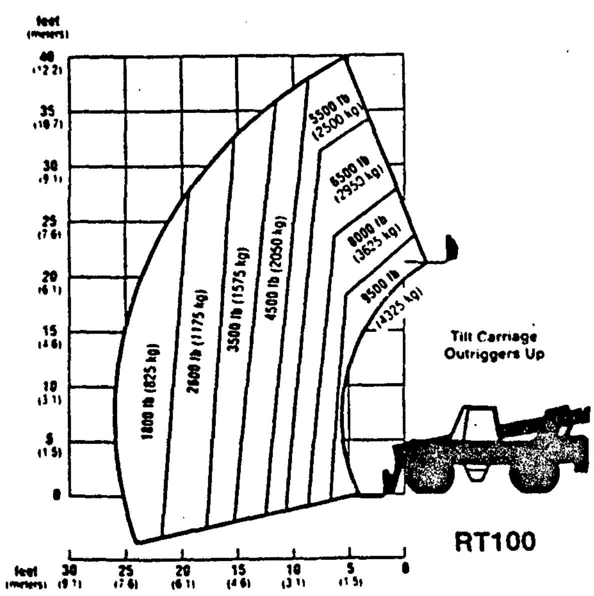


Figure 9.1.2-5 Tilt Carriage Outriggers Up

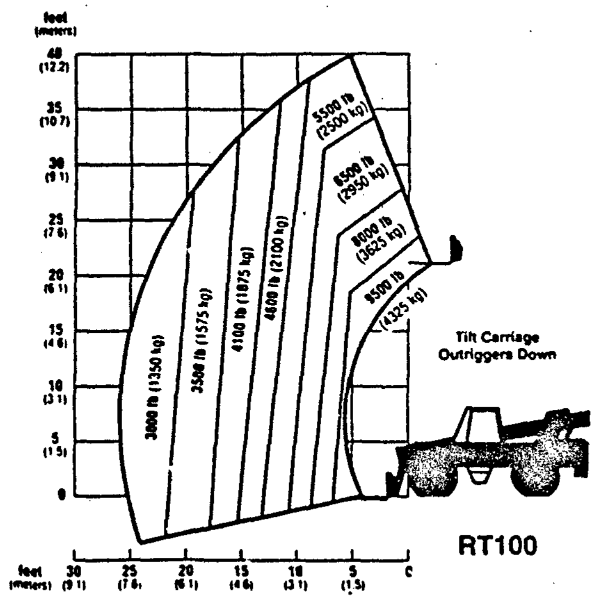


Figure 9.1.3-6 Tilt Carriage Outriggers Down

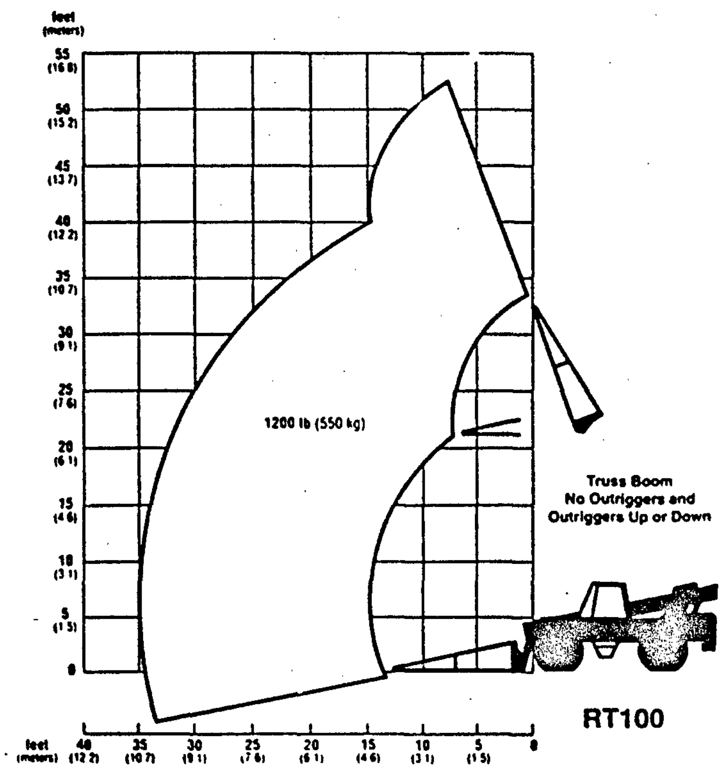


Figure 9.1.2-7 Truss Boom, No Outriggers and Outriggers Up or Down

Capacity charts for the fixed carriages, side-tilt carriages and 12 ft (3.7 m) truss boom are standard. The framer's carriages use the same load charts as the narrower carriages. Both machines have the same capacity with a truss boom, since the maximum truss boom capacity is limited by the tilt linkage.

There are two sets of capacity charts: one set for machines without outriggers and a second set for machines with the optional outriggers. With the outriggers down, capacity at reach increases, up to 1,000 lb (450 kg) at full forward reach.

However, machines equipped with outriggers have slightly reduced capacities at reach when the outriggers are raised, compared to machines without the outrigger option. While setting the outriggers enhances lateral and longitudinal stability, they do not increase capacity at full height.

9.1.3 Blocks Slider. Low friction nylon slider blocks contribute to smooth boom operation.

9.1.4 Coupler. A hydraulically operated attachment coupler permits the operator to change attachment without leaving the cab.

9.2 Alternative Design.

The ATLAS boom design will be a modified version of the RT100 design. No significant changes are required to accommodate the capacity with 24 inch load centers.

9.2.1 MLRS (Multiple Launch Rocket System) Pods. Redesign of the boom head section is required to load/unload Multiple Launch Rocket System pods within the 18 inches of head clearance provided.

9.2.2 Boom Angle. The boom angle will be restricted to 45 degrees.

9.2.3 ISO Container. Maturation of the ATLAS requirements to stuff/unstuff a 40 ft. ISO container will require a new boom design.

9.2.4 Level Crowd. Level crowd is accomplished electronically instead of hydraulically extending/retracting a slider mounted boom and pedestal.

9.2.5 Corrosion Protection. The zinc rich coating will provide the desired corrosion resistance. Special attention must be provided to coating, draining, sealing, etc. of the interior of the Boom Head Section Assembly. This assembly will be subjected to periodic immersion into the salt water, were as the balance of the boom assembly will be subjected to splash and spray only.

Lubrication of the Chain Group of the Telescoping Group may provide the only corrosion protection necessary as this group will not be immersed.

Implements including forks must be coated and the corrosion coating maintained.

9.3 Performance.

Implementation of the boom group will not compromise the performance of ATLAS. Maturation of the ATLAS requirements to stuff/unstuff a 40 ft. ISO container will require a new boom design.

9.4 HFE/Safety.

Implementation of the 3-pc boom and end effecters will not compromise HFE/Safety.

9.5 Reliability.

Implementation of the 3-pc boom design will not compromise reliability. The reliability allocation (MTBF= 10,000 hours) may be conservative given the moderate duty cycle of ATLAS when compare to more severe commercial applications.

9.6 Producibility.

Implementation of the 3-pc boom design will not compromise producibility. Special consideration may be given to the Boom Head Section Assembly to assure that the interior of the rectangular section is primed with the corrosion resistant primer.

9.7 Cost Impact.

Implementation of the 3-pc boom design will not contribute substantially to cost growth. Some cost growth will occur, however, if the requirement to stuff/unstuff a 40 ft ISO container is added.

9.8 Integrated Logistic Support.

The simple boom design make reliability of little concern. The few internal systems (telescoping cylinder) are reliable,and durable, and designed for easy maintainance. Components inside the boom are designed for easy removal and installation. Even the telescoping cylinder can be removed without complete disassembly of the boom. Provisioning requirements are minimal for the boom.

9.8.1 Slider Blocks. Boom slider blocks have drilled and tapped holes in the ends to facilitate installation and maintenance.

9.8.2 Boom Props. Boom Props are provided to support the boom when maintenance personnel are required to work under the boom.

Paragraph 10.0
Tires

10.1 Baseline Description.

10.1.1 Tire Size. The RT100 uses 14.00 x 24 12-ply tires to match to its weight, capacity, and performance requirements. The tires are tubeless and have a polyester cord, bias-ply construction with a self-cleaning loader lug tread pattern.

10.1.2 Rim. The tires mount on 24 in (610 mm) diameter, one-piece, drop-center rims. The single-piece rims are more durable and easier to work on than split rims. Each wheel is secured to the axle hub with ten lug nuts for extra strength.

10.1.3 Hydrofill. Hydrofill is required in all tires. The hydrofill is a solution of calcium chloride (CaCl) and water that is used to add weight in the tires for additional capacity at reach and better lateral stability. The calcium chloride acts as anti freeze to lower the freezing point of the solution. Since the hydrofill is required to achieve rated capacities, care must be taken to insure the proper amount of hydrofill is maintained in the tires.

10.2 Alternative Design.

10.2.1 Tires. The primary tire size considered for ATLAS is the 20.5Rx25 (525/80R25) to meet speed, mobility, and load requirements (Figure 10.2.1). As a result of the C130 Transportability Study, a transport vehicle configuration has been identified that will provide drive on/off within the 102" width restriction.

GP-2B
RADIAL OFF-THE-ROAD TIRE

A new, non-directional radial tire for use on front end loaders, motor graders, scrapers, and articulated dump trucks

Outstanding features include
- Superb Traction
- Excellent Mobility
- Long Tread Life
- Improved Fuel Economy

ENGINEERING DATA

Size	SM	TT TL	Design Rim Wdth	Infl. psi	Bar	Load lb	Load KG	Over'l Width in.	Over'l Width mm	Over'l Dia. in.	Over'l Dia. mm	Loaded Section & Growth in.	Loaded Section & Growth mm	Static Loaded Radius in.	Static Loaded Radius mm	Revs Per Mi	Revs Per Km	Gross Contact sq. in.	Gross Contact sq. cm
FOR LOADER/DOZER SERVICE — 5 MPH Maximum/10 km/h (Wide Base Sizes)																			
15 5R25	*	TL	12 00-1 3	73	5 00	12800	5800	15.5	394	50.0	1270	18.0	458	22.4	570	420	261	185	1194
17 5R25	*	TL	14 00-1 5	73	5.00	15700	7100	17.5	445	53.0	1346	20.0	508	23.6	599	396	246	230	1487
20.5R25	*	TL	17 00-2.0	73	5.00	20900	9500	21.0	533	57.9	1471	24.0	610	25.7	653	363	225	288	1860
23 5R25	*	TL	19 50-2 5	73	5.00	26800	12150	24.1	612	63.3	1608	27.8	706	28.2	718	332	206	372	2402
26.5R25	*	TL	22 00-3 0	73	5.00	33100	15000	26.6	676	68.4	1737	30.3	770	29.9	759	307	191	485	3141
40 5/75R39	**	TL	32 00-4 5	73	5 00	83500	37500	41.2	1045	101.4	2576	47.8	1214	43.8	1113	201	125	1145	7387
FOR GRADER SERVICE (G2) — 25 MPH Maximum Speed																			
15.5R25	*	TL	12.00-1.3	45	3.75	5740	2900	15.5	394	50.0	1270	17.5	445	22.9	582	420	261	165	1065
17 5R25	*	TL	14 00-1 5	45	3.75	6850	3450	17.5	445	53.0	1346	19.4	493	24.2	615	396	246	205	1341
20 5R25	*	TL	17.00-2.0	45	3.75	9150	4625	21.0	533	57.9	1471	23.4	594	26.4	678	363	225	260	1677
23 5R25	*	TL	19 50-2.5	45	3 75	11700	6000	24.1	612	63 3	1608	27.1	688	28.9	735	332	206	337	2174
FOR EARTHMOVER SERVICE — 30 MPH Maximum/50 km/h																			
15 5R25	*	TL	12 00-1 3	54	3 75	7850	3550	15.5	394	50.0	1270	17.5	445	22.9	582	420	261	165	1065
15 5R25	**	TL		76	5 25	9900	4550	15 5	394	50.0	1270	17.5	445	22.9	582	420	261	165	1065
17 5R25	*	TL	14 00-1 5	54	3.75	9100	4125	17.5	445	53.0	1346	19.4	493	24.2	615	396	246	205	1341
	**	TL		76	5 25	12000	5450	17.5	445	53.0	1346	19.4	493	24.2	615	396	246	205	1341
20 5R25	*	TL	17 00 2 0	54	3 75	12300	5600	21 0	533	57.9	1471	23.4	594	26.4	678	363	225	260	1677
	**	TL		76	5 25	16100	7300	21 0	533	57.9	1471	23 4	594	26.4	678	363	225	260	1677
23 5R25	*	TL	19 50 2 5	54	3 75	15700	7100	24 1	612	63.3	1608	27.1	688	28.9	735	332	206	337	2174
	**	TL		76	5 25	20400	9250	24 1	612	63 3	1608	27.1	688	28.9	735	332	206	337	2174
26 5R25	*	TL	22 00 3 0	54	3 75	19800	9000	26 6	676	68.4	1737	29.5	750	30.7	780	307	191	365	2355
	**	TL		76	5 25	25400	11500	26 6	676	68 4	1737	29 5	750	30.7	780	307	191	365	2355
40 5/75R39	**	TL	32 00 4 5	76	5 25	64000	29000	41 2	1045	101.4	2576	46 9	1191	44 0	1118	201	125	915	5899

GOODYEAR

Figure 10.2.1 The 20.5Rx25 is the tire size considered for ATLAS

The 17.5Rx25 (445/80R25) tire is an optional choice. It would provide an easier solution to C130 transportability, but at the expense of reduced mobility and vehicle stability. Depending on final ATLAS requirements, this could be a viable option. Each of the tire configurations are bi-directional to provide equal mobility forward or reverse. English designations of tire sizes refer to Goodyear tires tailored to off-road service. Metric designations refer to mobile crane tires with the high speed capability required of ATLAS.

10.2.2 Rims. The ATLAS rims for the 20.5Rx25 tires would be a new design to provide the desired rim-offset. In the standard configuration, the rim offset would be outboard providing a vehicle width of 108". In the C130 transport configuration, the rims-offset would be inboard providing a vehicle width of 101".

10.2.3 Hydrofill. Hydrofill would not be required to provide the ATLAS lift capacity.

10.3 Performance.

The tire size, load rating, braking requirements and operating pressure significantly impacts each aspect of the vehicle design including speed, lift capability, mobility, etc.

10.3.1 Capacity. The 20.5Rx25 tires provides a larger footprint for working in the soft underfooting typical of LOTS operations. The 17.5Rx25 tires require higher pressure for equal lift capacity. Increasing tire pressure reduces the footprint which decreases mobility.

10.3.2 Weight. Weight growth associated with implementation of the larger tires is a result of performance requirements for capacity, speed and mobility.

10.3.3 Vehicle Speed. The rolling radius of the tire impacts vehicle speed. The ATLAS requires an Load Rating E for sustained highway performance without cooling stops. Figures 10.3.3-1 and 10.3.3-2 provide Speed vs Permissible Tire Load at various tire pressures for the 20.5Rx25 and 17.5Rx25 tires respectively.

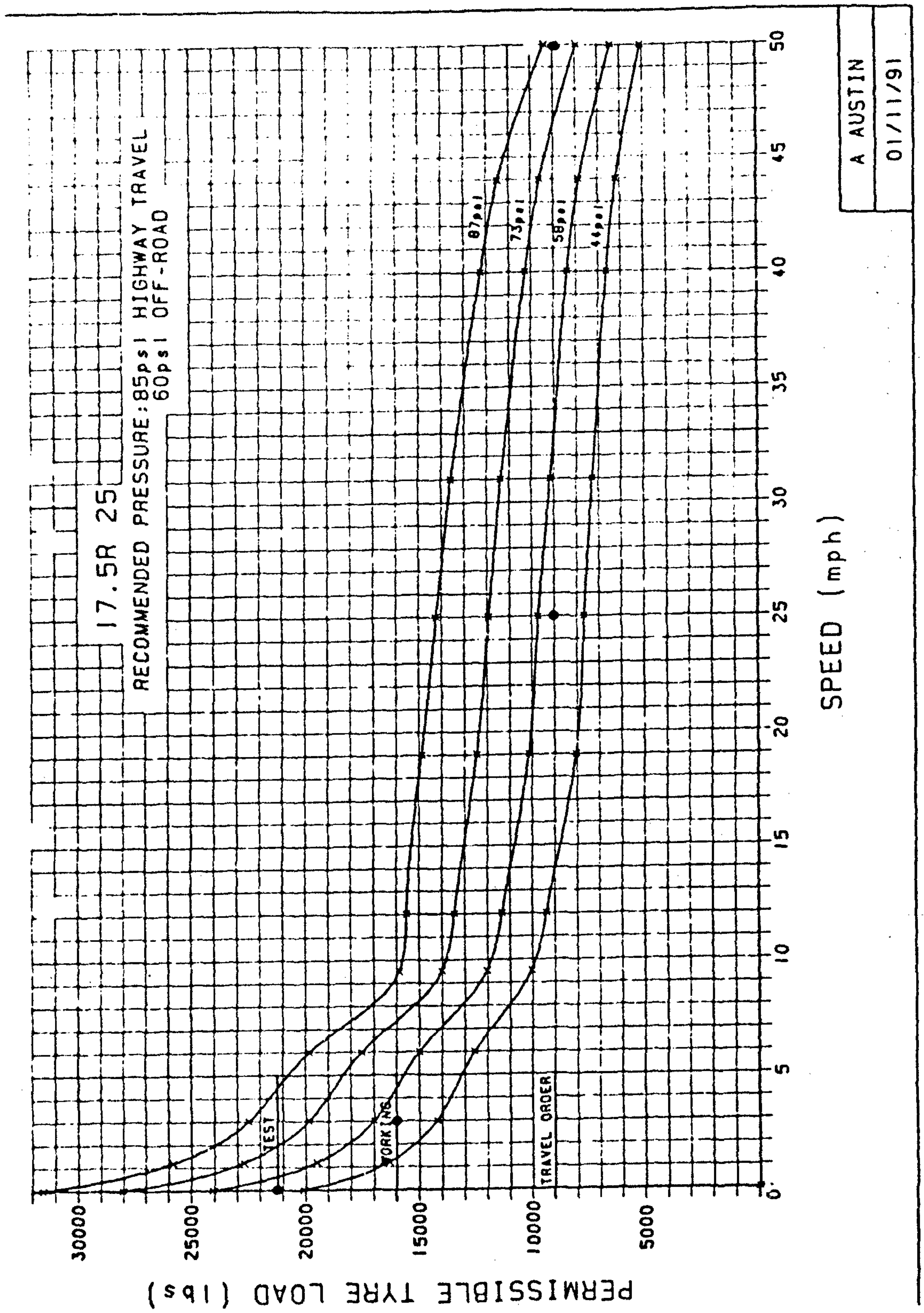


Figure 10.3.3-1 Speed vs Permissible Tire Load for 17.5Rx25 Tires

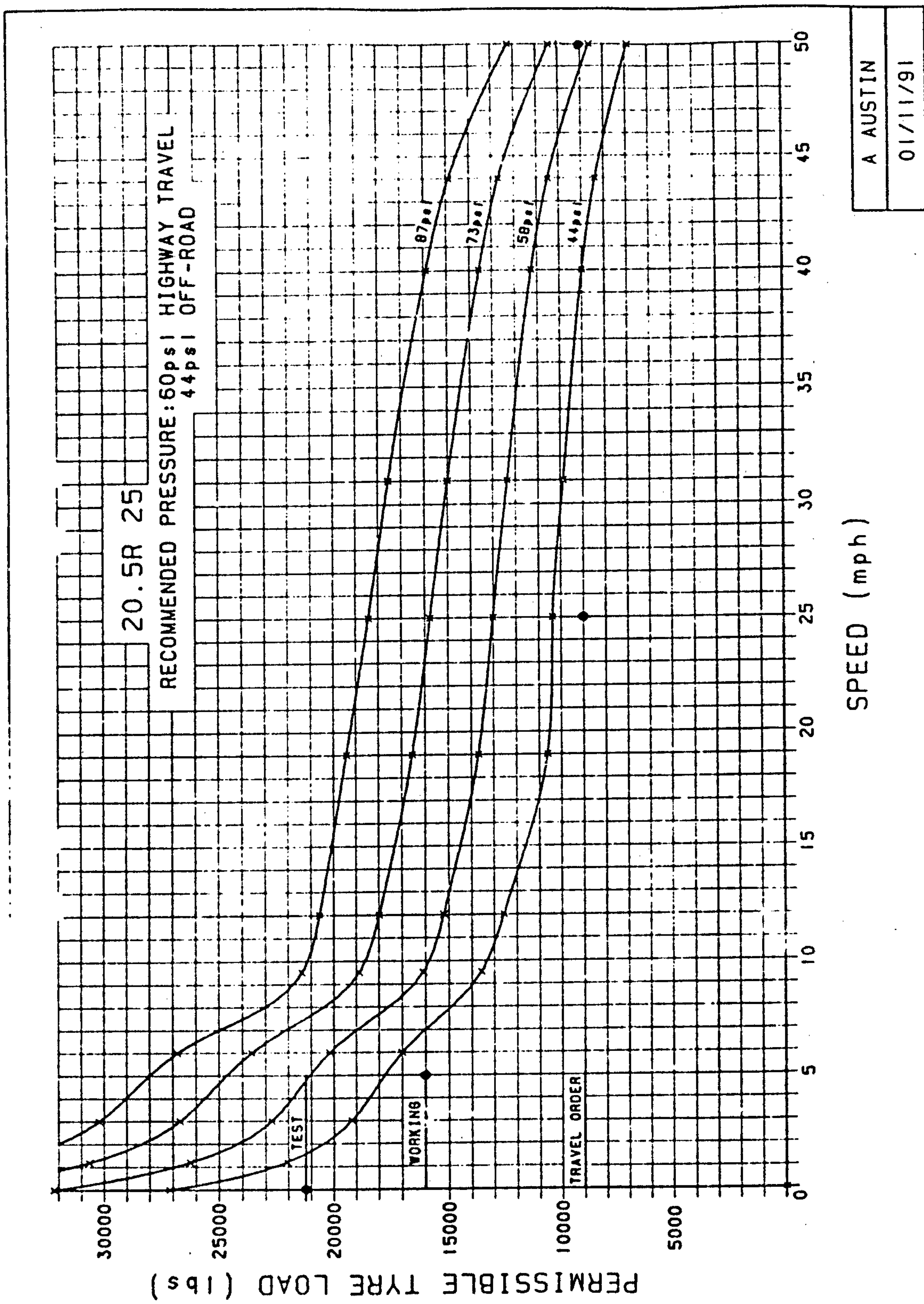


Figure 10.3.3-2 Speed vs Permi sible Tire Load for 20.5Rx25 Tires

The 20.5Rx25 tires are favored over the 17.5Rx25 tires to obtain the desired speed with an powertrain ratio of approximately 10:1. Secondly, the 20.5Rx25 tire would operate at lower tire pressures for both on and off road operations.

10.3.4 Fuel Consumption. Fuel consumption is influenced by tire selection, but would be dominated by factors other than tire size.

10.3.5 Vehicle Height. Vehicle height would be sensitive to tire selection. The 20.5Rx15 would increase the height of the ATLAS by 2 inches over the 17.5Rx15 tire without other configuration changes to the vehicle to offset the increase.

10.3.5 Ground Clearance. The 20.5Rx15 would increase the ground clearance of the ATLAS by 2 inches over the 17.5Rx15 tire. This increase provides a direct improvement in mobility. Final ground clearance will be determined by selection of the transmission.

10.3.6 Space Claim. Each of the tires will have different space claim requirements to provide the same steering angle per Figures 10.3.6-1 and 10.3.6-2 for 0° steering angle and 37 and 27.79 degrees respectively.

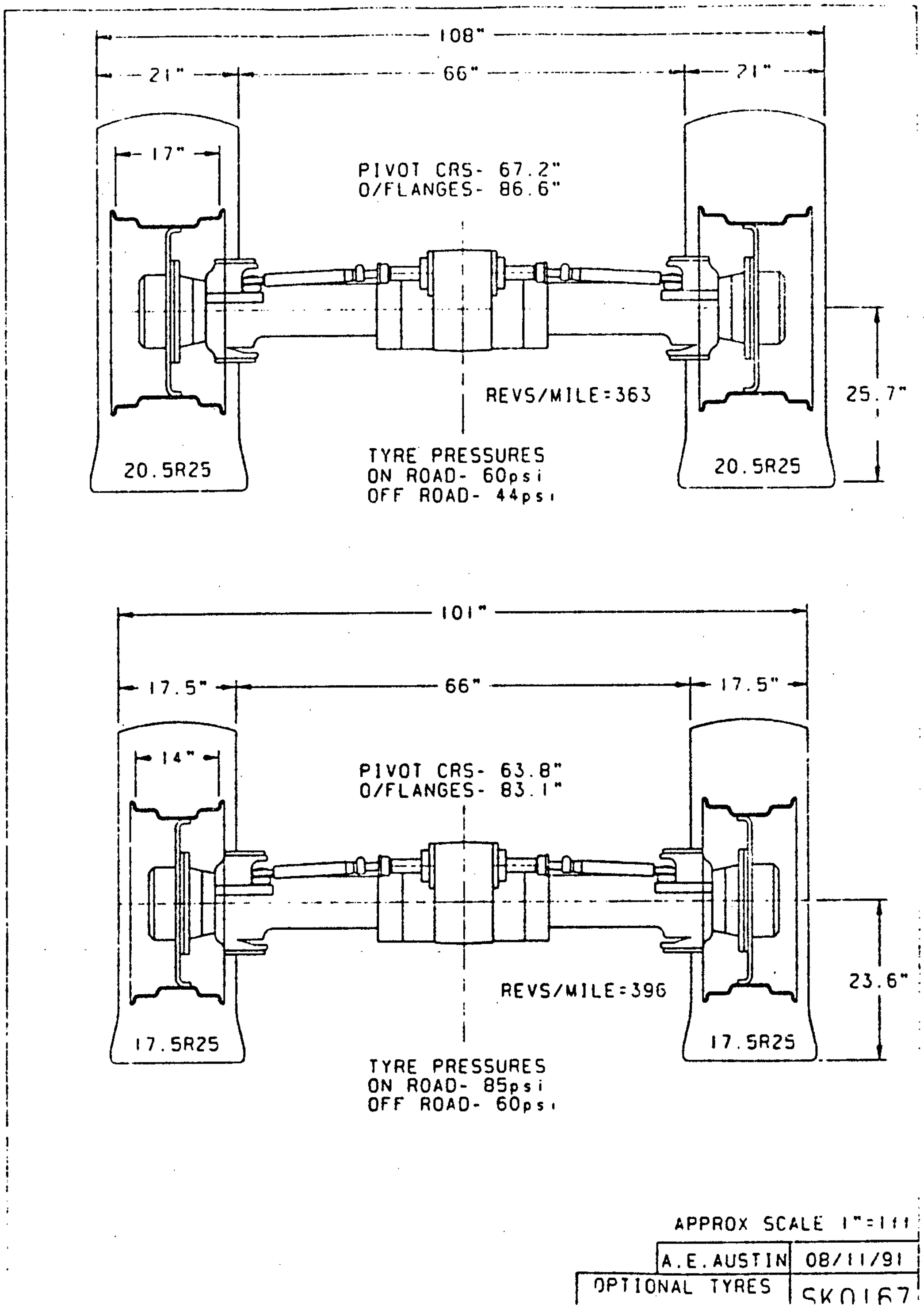


Figure 10.3.6-1 Space Claim Requirement at 0° Steering Angle

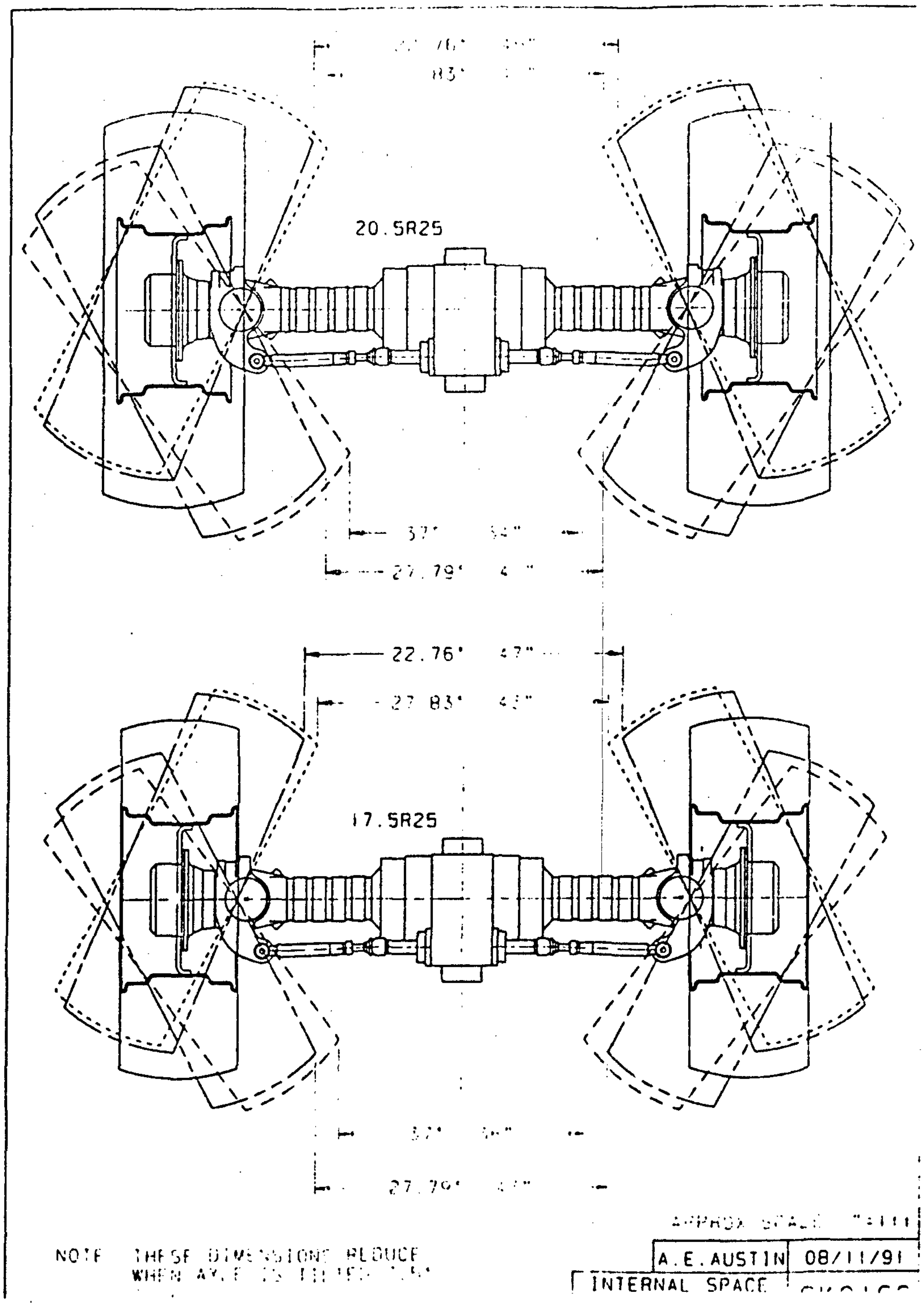


Figure 10.3.6-2 Space Claim Requirement at 37° and 27.79° Steering Angle Respectively

10.4 HFE/Safety.

Implementation of either the 17.5Rx25 or the 20.5Rx25 tire has not projected impact of HFE/Safety.

Implementation of the 20.5Rx25 tire with a 108" vehicle width will improve side slope stability of ATLAS and reduce the probability that the operator can overturn the vehicle.

10.5 Reliability.

The 20.5Rx25 tire will be more durable (reliable) for ATLAS loading conditions. Either tire provides comparable side wall construction to the earth moving (off-highway) and maintaining the durability of the tire.

10.6 Producibility.

Implementation of either tire has no impact on producibility.

10.7 Cost Impact.

The increased procurement cost of the 20.5Rx25 tire, about $750 per vehicle, will be offset by the lower owning and operating costs. Implementation of the 20.5Rx25 tire will reduce the life cycle costs of the axle.

10.8 Integrated Logistic Support. Reliability is enhanced with the alternative, 20.5Rx25 tires, with corresponding enhancement to the maintainability. Provisioning is not effected.

Paragraph 11.0
Microclimate Control

11.1 Baseline Description.

The baseline cooling system would either be fans, or an air conditioning system. Neither baseline meets the requirements for under garment cooling necessitated by the wearing of chemical protective overgarments.

11.2 Alternative Designs.

Several alternative technologies appear to meet the ATLAS microclimate cooling requirements. These cooling systems are currently in production, though not in large quantities.

11.2.1 The Cooling System. The cooling technologies are of three basic configurations. Vapor compression (air conditioning), thermo-electric, and thermal exchange systems all provide the cooled medium, either liquid or air, which is pumped through tubing to a cooling undergarment worn by the operator. Each system is briefly discussed.

<u>11.2.1.1 Vapor Compression.</u> Vapor compression uses standard engine mounted compressor, freon based cooling. This system would either require extensive modification to a vehicle mounted air cooling system, or a separate specialized cooling system dedicated to the micro-climate cooling role.

<u>11.2.1.1.1 Advantages Of Vapor Compression.</u> Advantages of vapor compression cooling are that the system would be highly integrated to the ATLAS system, the system would use existing air conditioner technology and the system be maintained at the unit or direct support level of maintenance.

11.2.1.1.2 Disadvantages Of Vapor Compression. The primary disadvantages are reduced reliability, and higher cost (both initial and life cycle) than other alternatives. The system is also directly integrated into the vehicle, eliminating any possibility for off vehicle use.

11.2.1.2 Thermo-Electric Cooling. Thermo-electric cooling uses the property of (Peltier Effect) electric current passed through two dissimilar metals creating a temperature differential between the metals, to generate a cooling effect. The power requirements of this system are not expected to require a larger alternator from the baseline configuration. A pump or fan is required to transport the medium (water or air) to the vest of the operator.

11.2.1.2.1 Advantages Of Thermo-Electric System. The primary advantage of this system is its high reliability. The pump or fan unit, which transports water or air from the cooling unit, through tubing, to the cooling vest worn by the operator, is the only element with moving parts. The thermo-electric cooling unit itself has very high reliability. The unit could be mounted, when needed, in the cab. This would require an electric source (outlet) located within the cab. The system also has the advantage of being portable, for a limited time, if external battery packs are available. Some portions of the thermo-electric unit may be damaged while the system still operates effectively. Thermo-electrics may also be used for heating without modification.

11.2.1.2.2 Disadvantages Of Thermo-Electric System. The primary disadvantage of the thermo-electric option is its inherent reduction in cooling effect as ambient temperature increases. Thermo-electrics create a temperature differential between dissimilar metals. Temperatures on both hot and cold metal increase as ambient temperature increases. So the cooling effect is reduced as ambient temperatures increase. The cooling effects of thermo-electrics are still excellent at 120 degrees F. Ambient temperatures above this level will rapidly reduce the cooling effect. So, the acceptability of this type of cooling system will depend on the requirements of ATLAS. The thermo-electric unit is not complex, but could not be repaired at the using unit.

11.2.1.3 Thermal Exchange. The third cooling method, thermal exchange, uses an external source for cooling medium (usually ice, though more exotic mediums such as phase-transition crystals may be used). The system consists of the same vest and pump type units used in the two preceding concepts. The difference is that cooling tubes, in an insulated container, provide the cooled liquid for cooling effect. Several reports on this system, in use at the National Training Center, are provided. The reports indicate that the ice cooling units needed new ice only once every two days. Thermal exchange units have a much higher inherent capacity to cool in extreme climates. Thermal exchange is also less costly.

11.2.1.3.1 Advantages Of Thermal Exchange. The major advantage of this system is its simplicity of design, creating an increase in reliability and reduction in cost. A major advantage of this system, over vapor compression and thermo-electrics, is the much higher cooling effect which may be created by the system. Vapor compression and thermo-electric's are limited by the size of their compressor and electric cooling units respectively. Though the pumps can easily transport more coolant, the systems have strict limitations on cooling rate. The ice based thermal exchange system easily responds to extreme temperature requirements with a simple increase in pump rate. Minimal vehicle power is needed to operate the system. This system is easily adaptable for off vehicle use, with minimum battery power necessary to transport the cooling liquid to the user.

11.2.1.3.2 Disadvantages Of Thermal Exchange. The major disadvantage of thermal exchange systems are their reliance on external sources of coolant and the periodic need to recharge the units' coolant. Requirements for ice could be infeasible in a war environment.

11.2.1.4 Combination Cooling Unit. A point to be noted is that a combination cooling unit could be developed if required. An example would be a thermo-electric unit for temperatures up to 120 degrees, with provisions to allow attaching an ice based cooler (the insulated container and lines) to the lines leading to the thermo-electric units pump. This provision could be included, if the requirement exists, with only minor cost impact on the base thermo-electric cooling unit. This could meet the rare requirement for use in extreme temperatures up to 160° F.

11.2.2 The Cooling Medium. Cooled liquid or air are the two mediums used to actually cool the operator. Each has advantages and disadvantages. Both methods are in use and both appear to successfully cool the operator.

<u>11.2.2.1 Liquid Cooling.</u> Liquid cooling has the advantages of increased thermal efficiency and a liquid "clean" environment. Though not documented, liquid cooling is thought to reduce human. Liquid cooling systems, typically either thermo-electric or thermal exchange systems, would most likely have the entire unit within the cab. This location reduces the possibility of the system developing leaks.

The major disadvantage of liquid cooling is the inability to reduce humidity effects on the operator (this is a comfort factor). Other disadvantages are:

a) A potential increase in maintenance requirements (over an air cooled system) if the system is used infrequently.

b) An increased risk of system failure should the cooling garment/tubing leak (leaking could compromise the effectiveness of the chemical protective overgarment).

c) The space requirements of the cooling system, should the cooling unit be mounted within the cab. The space problem could be minimized through either cooling unit or cab design.

<u>11.2.2.2 Air Cooling.</u> Air cooling has the advantage of being able to reduce the humidity within the operator's environment.

The major disadvantage is the requirement to filter air prior to reaching the operator. Leaks in tubing could allow chemicals to directly violate the integrity of the chemical protective overgarment. A further disadvantage is the reduced thermal efficiency of air as a cooling medium. It requires a larger, costly cooling unit. A third disadvantage, is the potential dehydration of the operator due to the convective cooling of the air. A 3% water loss contributes to a decrease in operator performance.

11.2.3 Cooling Vest. The cooling system transports cooled air/water to a location under the chemical protective overgarment. This usually consists of a vest worn under the overgarment. The vest can be augmented with either cooling pants and/or a cooling hat. Generally the vest is used for general cooling. Interestingly, the cooling hat seems to provide a similar level of cooling as the entire vest. This is due to the increase requirements for body cooling created by the insulating layer of body fat in the torso. The head cooling hat seems to provide the same amount of overall body cooling. A question has been raised about head cooling and possible head aches this system could create. Actual use of head coolers, with no body vest (this is currently done commercially for auto racing), has indicated no problems with headaches or other physiological problems. It is recommended that the Government consider using head and vest cooling as opposed to just vest cooling. This should provide an excellent level of cooling, whereas the vest just alone provides what may be termed an acceptable level of cooling.

11.3 Performance.

The alternative designs all provide an acceptable level of cooling, up to the 120° F. Above 120°F, thermo-electrics degrade in performance. Vapor compression cooling can cool above this level but require a larger compressor and stronger tubing required throughout the system. This would have a negative effect on system reliability and cost. Thermal exchange has the highest potential level of cooling, limited only by the requirement for external sources of coolant. Vapor compression has some potential effect on engine performance. Thermo-electrics and thermal exchange should have no effect on engine performance. Air cooling requires a substantial increase in cooling unit size to compensate for air cooling inefficiencies.

11.4 HFE/Safety.

Human factor engineering issues are important to micro-climate cooling. Specifically, what constitutes "cool" is still open to wide interpretation. This basic issue and the current lack of standards, create a risk of the Government not receiving a capability level desired. The major objective is to ensure the operator's performance is not degraded while working in a high ambient temperature environment in chemical protective overgarments.

11.4.1 Cooling Capacity. A recommended baseline is to require 300 watts of cooling to the operator. This would put limits on the system's ability to perform when additional cooling is required, but would establish a performance specification for whatever system is chosen.

11.4.2 Cooling Medium. This determination would drive the choice of cooling methods. In particular, the question of dehydration effect on user performance should be analyzed (to determine its relevance) before making a decision on liquid vs. air cooling. Additionally, the small amount of sweating when liquid cooling should be analyzed to determine if this is relevant.

11.4.3 Cooling System Hardware. A human factor question relates to the tubing running from the cooling unit, under the overgarment, to the user. Questions of how to allow user movement, while not providing excessive tubing must be addressed.

11.4.4 Control Logic. The interface desired between the cooling unit and the user is another operating issue. A manual cooling adjust (thermostat) is simplest, but requires effort and thought to monitor. A method of automatically controlling the level of cooling/comfort may be difficult.

11.4.5 Vest Durability. The durability of the cooling vest is a concern. Due to the complicated nature of the vest, its durability is limited. As long as extended use (months) is not anticipated, this is not a problem. The anticipated level of use should be determined by the Government to ensure that an acceptable level of durability is designed into the cooling vest.

11.4.6 Other Cooling Considerations. No requirement for operator cooling, other than micro-climate cooling, has been identified. A requirement for non-chemical environment cooling could require standard air conditioners or a duty cycle for the micro-climate cooler in a non-chemical environment.

11.4.7 Safety. The largest safety related question has to do with potential violations to the integrity of the protective overgarment. Though potential violations are unlikely, the risk to the individual is great.

11.4.7.1 Safety-Liquid System. The liquid system can reduce the effectiveness of the protective suit should it leak and saturate the overgarment with liquid. This may provide an avenue for chemicals to reach the user. If the system leaks freon gas injested through the engine generates phosgene gas (in small quantities).

11.4.7.2 Safety-Air System. The air system can leak, and with negative pressure effects, directly transport chemical agents to the user.

11.5 Reliability.

The reliability of all three cooling alternatives is high. Vapor compression would have the lowest inherent reliability, with thermo-electrics higher and thermal exchange having the highest reliability. The durability of the cooling vests is limited and may create reliability concerns, should the expected level of use be high. By its permanent installation on the ATLAS, the vapor compression system would be exposed to weather and compressor use throughout its life. The thermo-electric and thermal exchange systems could be stored off vehicle, but would require periodic preventative maintenance/inspection. None of the systems has seen extensive use, so long term reliability of the alternatives is uncertain. Reliability allocation is 4000 hours.

11.6 Producibility.

Producibility of all systems has been proven through commercial and military use. Several producers surged to support various militaries during Desert Storm.

11.7 Cost Impact.

The baseline vehicle does not contain a micro-climate cooling feature. Cost impact may be high, approximately $10,000, depending to the alternative desired. Additionally, cost impact for vehicle interface will be a factor (this includes any required cab interface and mounting considerations). An additional cost will be associated with any decision to permanently mount the cooling system, or to store off vehicle. If external sources of coolant (ice) are available, the thermal exchange system is by far the least expensive. If no external source of ice is available, then thermal electrics becomes the least expensive, for environments up to 120 degrees F. Should extreme temperature cooling be required, then either thermal exchange or vapor compression will be necessary.

11.8 Integrated Logistic Support.

Reliability of the micro-climate cooling systems is relatively high. Interestingly, the most expensive alternative, vapor compression, is the least reliable and the least expensive, thermal exchange, has the highest reliability. Other performance related factors will determine which system is appropriate. The relationship for reliability holds true for maintainability also. The vapor compression system would have the worst maintainability and highest life cycle cost, the thermal exchange system the best maintainability and lowest life cycle cost, with the thermo-electric system falling in between.

Durability of the cooling systems is high for all alternatives. But, a weak point in all systems is the cooling vest. The vest will not hold up well to extended use, due to the need for a thin layer of material between the cooling tubes/passages and the user. Additionally, all systems have limited puncture resistance.

New provisioning will be required for this system.

Paragraph 12.0
Stabilizers

12.1 Baseline Description.

Hydraulic outriggers (also known as stabilizers) are available as an option. The advantage of outriggers is that they enhance lateral and longitudinal stability, and significantly increase lift capacity at maximum reach. Disadvantages include higher cost, slower cycle times, and slightly lower capacity at reach when the outriggers are raised compared to a standard machine.

The outriggers bolt to the main frame so once they are down the chassis cannot be leveled with the frame leveling control. On uneven terrain, the frame should be leveled first, then the outriggers should be lowered into place and adjusted to ensure the chassis remains level. Like frame leveling, the outriggers should not be operated after the boom is raised.

12.2 Alternative Design.

Outriggers, though precluded from consideration on the 6K RTFLs per MIL-T-5058, may have a role within ATLAS with respect to LOTS operations and are anticipated increase in lift/reach requirements. Historically, outriggers have been considered to increase cycle times and provide additional opportunities for operator error.

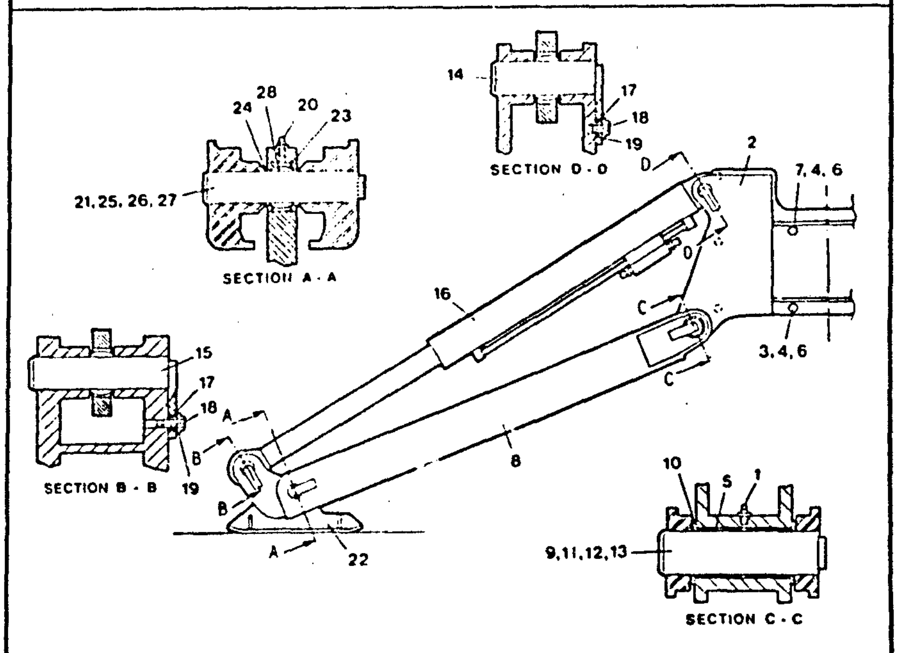
Stabilizers provide a lift capability at full boom extension that would not otherwise be possible with an RTFL of that GVW and boom reach. For example, the lift capacity of the RT100 increases by 67% at full boom extension.

Stabilizers would not be required for typical lift and carry operations. Stabilizers may be required when ATLAS lift at reach capabilities are increased.

12.2.1 LOTS Operations. LOTS operations, conducted in sand with soft underfootings, may required a stabilizer to lift loads at full reach. The stabilizers would share the front axle load to reduce front tire sinkage.

12.2.2 Stabilizer Design Consideration. ATLAS stabilizers could be commercial systems like the one shown in Figure 12.2.2-1 (optional commercial outrigger group) or they could be tailored to the requirements of ATLAS.

FRAME AND PANELS (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3B8488	2	GREASE NIPPLE		15	8Q2086	2	PIN AS
	2	6R8943	1	BRACKET AS	YNSS	16	844103	2	OUTRIGGER RAM GROUP
M	3	6V3669	8	BOLT		17	[illegible]338	4	SLEEVE
	4	6V7742	10	NUT	M	18	[illegible]195	4	BOLT
M	5	897352	4	BUSH	M	19	8T[illegible]222	4	WASHER
M	6	8T3282	10	WASHER		20	3B8488	2	GREASE NIPPLE
	7	986000	2	BOLT		21	6R8983	2	PIN AS
	8	6R8955	2	OUTRIGGER BEAM AS		22	844005	2	OUTRIGGER FOOT AS
	9	6R8978	2	PIN AS		23	844[illegible]	4	CIRCLIP INTERNAL
	10	6R8985	4	WASHER		24	844[illegible]	4	SPACER
	11	897338	2	SLEEVE		25	897[illegible]	2	SLEEVE
M	12	8T4195	2	BOLT	M	26	8T41[illegible]	2	BOLT
M	13	8T4222	2	WASHER	M	27	8T422[illegible]	2	WASHER
	14	6R8981	2	PIN AS		28	975448	2	SPHERICAL BEARING

M METRIC PART NSS NOT SERVICED
Y SEPARATE ILLUSTRATION

P6R8977 Y
REV 002

6R8977 OUTRIGGER BEAM GROUP

Figure 12.2.2-1 Optional Commercial Outrigger Group

12.3 Performance.

Outriggers would influence the performance of ATLAS.

12.3.1 Capacity. The ATLAS boom design would provide the desired lift capacity of 4000 lbs at 20.5 ft and 10,000 lbs at 4 ft. Lift capacity would be less at minimum extension when the stabilizers were not in use. Commercially the lift capacity of the RT100 is reduced by 200 lbs at minimum extension.

Paragraph 9.0, Boom and End Effectors provides the capacity charts, with and without stabilizers, for the RT100.

12.4 HFE/Safety.

Implementation of stabilizers introduce an additional operation that the operator would be required to perform (Figure 12.4-1). Adding to the operator typically increases the probability for operator error. Maturation of the ATLAS load sensing and boom controls in combination with a stabilizer sensor may provide the opportunity to address safe-fail limitations.

Use of Outriggers (if equipped)

⚠ WARNING

Incorrect use of outriggers could cause an accident resulting in injury or death. Do not use the outriggers except as described in the following instructions

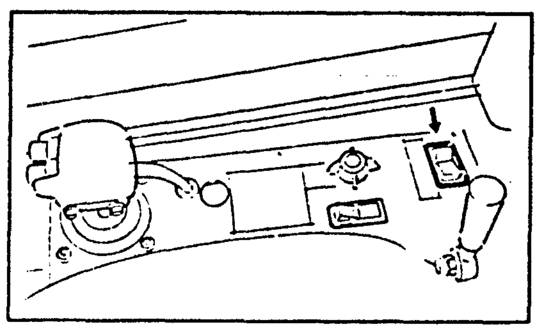
Machines equipped with outriggers are capable of handling heavier loads at some boom angle and length combinations when the outriggers are lowered.

The stability of the machine at all boom angle and length combinations is increased when outriggers are used, but DO NOT rely on stability alone as a guide to maximum capacity. Maximum capacity is determined by factors other than stability at some boom angles and lengths.

The outriggers must always be used in conjunction with the correct load chart and the capacities shown should never be exceeded.

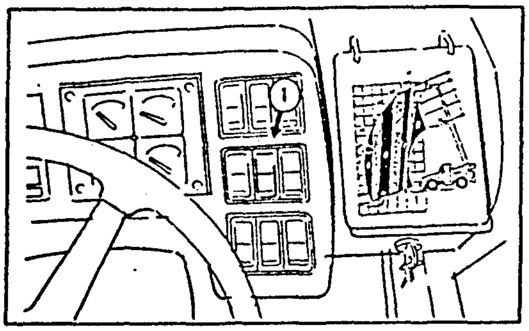
The boom must be fully retracted and lowered to the travel position before lowering the outriggers. Ensure the areas adjacent to the outriggers are clear and will provide uniform support for the weight of the machine and intended load.

Use the following procedure for lowering the outriggers:

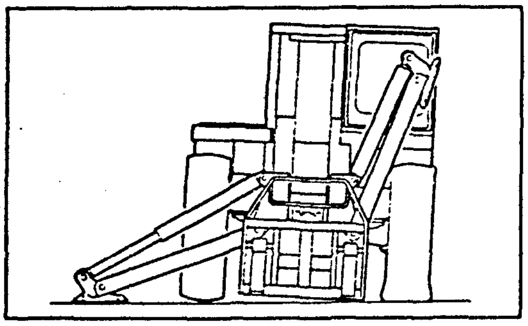


1. Level the machine using the frame level control and the level indicator. Do not use the frame level control after lowering the outriggers.

Figure 12.4-1 Part 1 Operator Instruction for use of outriggers.

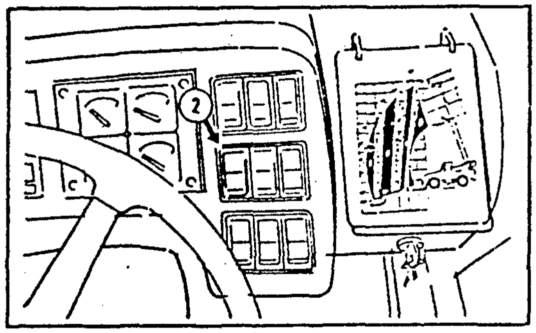


2. Press the panel switch (1) to lower the right outrigger. Hold the switch until.....

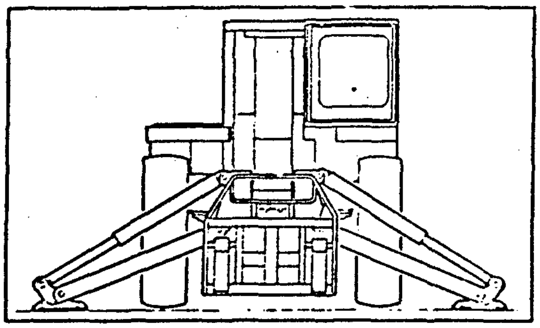


.....the outrigger lifts the right tire clear of the ground then release.

Observe the area where the outrigger is moving to ensure there are no obstructions.



3. Press the panel switch (2) to lower the left outrigger. Hold the switch until.....



.....the outrigger lifts the left tire clear of the ground. Adjust the position of the left outrigger to level the machine then release the switch. The front wheels must remain just clear of the ground.

Observe the area where the outrigger is moving to ensure there are no obstructions.

Before raising the outriggers, fully retract and lower the boom to the travel position. Ensure that both outriggers are FULLY raised before travelling with the machine.

Figure 12.4-1 Part 2 Operator instruction for use of outriggers.

12.5 Reliability.

Stabilizers would add to the overall complexity of ATLAS and decrease to the reliability of the system. This reduced reliability may be accommodated within the reserve allocation.

12.6 Producibility. Producibility of stabilizer group would be comparable to the commercial outrigger group. Only vehicle assembly time would be moderately impacted by implementation of a stabilizer group.

12.7 Cost Impact.

Implementation of a stabilizer group would contribute to procurement an:l :ife cycle costs. Application of commercial components, i.e., hydraulic cylinders, lines, v:lves, etc., would minimize the cost growth. New design would be limited to the structural components of the stabilizer group, though changes in the chassis design may be considered to meet ATLAS requirements.

12.8 Integrated Logistic Support.

Reliability would be reduced by addition of this system. Maintenance costs would also rise correspondingly. The degradations are offset by the increased performance potential of ATLAS. Provisioning costs would also increase slightly.

Paragraph 13.0
CCTV

13.1 Baseline Description.

The RT100 does not provide for a Closed Circuit Television (CCTV).

13.2 Alternative Design.

The CCTV system (Figure 13.2-1) considered provides supplemental vision to assist the operator in locating and engaging the load (within an ISO container for example), traveling, and finally placing the load in a safe and reliable manner.

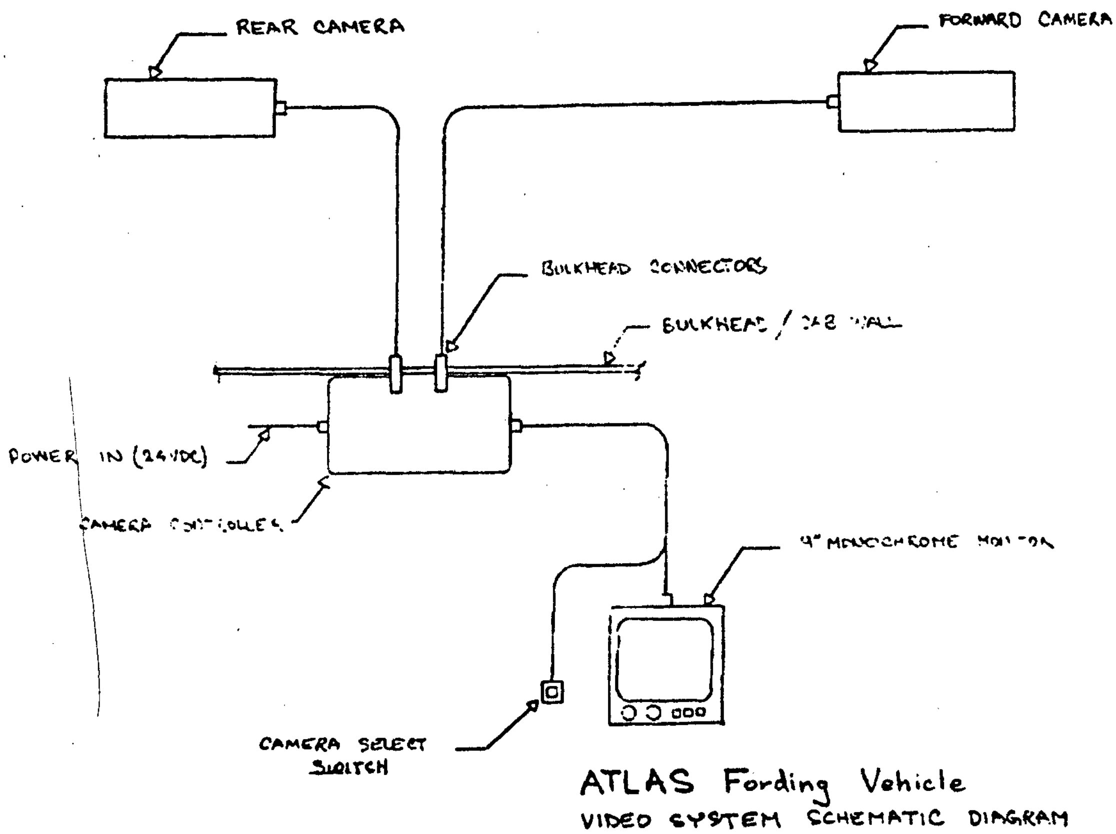


Figure 13.2-1 CCTV System

The CCTV consists of:

- 2 *Series 200 cameras with pedestals*
- 1 *Series 200 camera control unit*
- 1 *9-inch high resolution video monitor*
- 1 *Camera select switch*
- 1 *Set of external cables and connectors*
- 1 *Set of bulkhead connectors*
- 1 *Set of internal cables and connectors*
- 1 *Set of mounting hardware*
- 1 *User manual*

13.2.1 Camera-Forward. The forward looking camera is mounted on the upper most boom extension over looking the loading forks. This camera has approximately 70° field of view and is in focus throughout the full working distance of the vehicle. The auto iris camera lens and camera automatic glare control (AGC) system allows effective operation from full sunlight to head light lit night conditions.

13.2.2 Camera-Rearward. The rear camera is mounted such as to give a wide angle view of the center and right rear areas of the vehicle. Field of view of this camera may be adjusted by the appropriate selection of camera lenses.

13.2.3 Cabling. Cabling to both cameras is enclosed in a chemical resistant flexible plastic jacket. The stainless steel camera connectors and bulkhead fittings are secured to the cable jacket with hermetic seals. All cables, connectors, camera housings and fittings are waterproof to 100 m and can withstand repeated exposure to harsh chemical and corrosive environments.

Cable routing to the forward camera will be provided through the boom; alternately, a side mounted reel may be considered if insufficient space or technical problems are identified.

13.2.4 Controller. The camera controller is mounted inside the vehicle cab and is also watertight with watertight connectors. This unit provides regulated power to the cameras in addition to providing the camera selection function. A switch on the vehicle instrument panel provides the camera select command to the camera controller.

13.2.5 Monitor. The 9-inch video monitor is mounted behind the vehicle instrument panel. Power and video signals are provided to this unit from the camera controller. A LEXAN faceplate protects the monitor CRT from damage and also provides a measure of glare reduction for outside light. Resilient shock mounts are fitted to limit the vibration to the monitor.

13.2.6 Series 200 Camera. The series 200 camera (Figure 13.2.6-1) is an environmentally secured, high resolution, monochrome, Closed Circuit Display unit. The external camera housing and mount is fabricated from 6061 grade aluminum with hard anodized finish. Stainless steel or mild steel is also available with a variety of finishes and paint options.

The 200 camera housing is totally environmentally sealed and is submersible to a depth of 100 m. Stainless steel and glass electrical bulkhead fittings are rated at 2000 psi operating pressure with gold on gold contact material for reliable low noise operation.

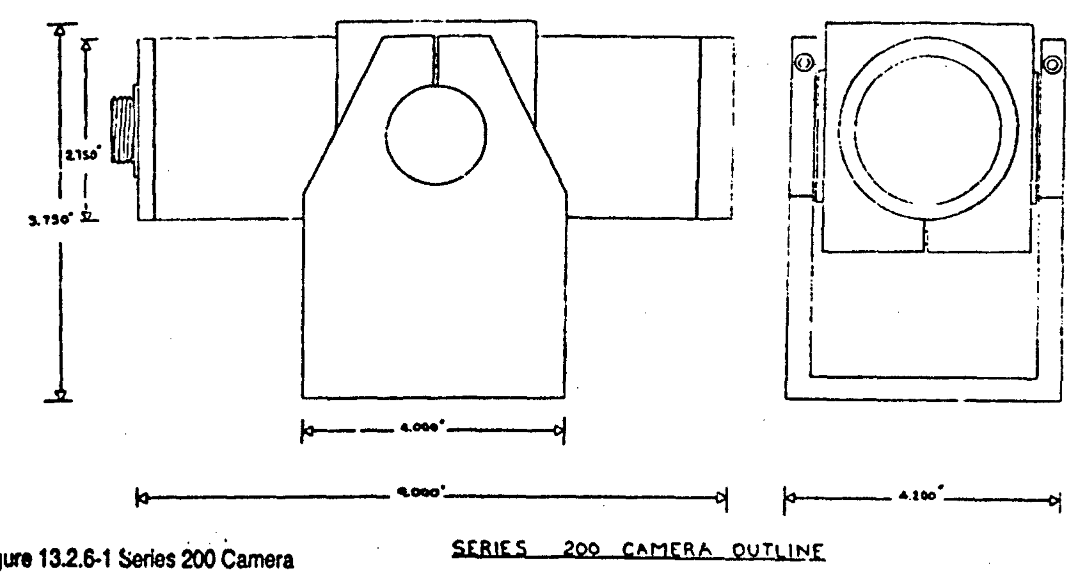


Figure 13.2.6-1 Series 200 Camera

Series 200 Camera Specifications:

Physical Dimensions:	*4.2" (w) x 5.75" (h)*
Weight:	*8.9 lbs (aluminum)*
Vibration Resistance:	*7G (11 Hz to 200 Hz)*
Shock Resistance:	*70G (non-repetitive)*
Operating Temperature:	*-20 to +50 degrees C*
Environmental:	*waterproof to 100 m*
Power Consumption:	*50 watts (with heater)*
Resolution:	*570 (H), 485 (V) TV lines*
Sensitivity:	*400 LUX*
S/N ratio:	*50 dB or better*
Minimum Sensitivity:	*0.5 LUX*
"C" mount lens:	*auto iris*

13.2.7 Series 200 Camera Controller. The series 200 camera controller accepts input from two cameras. Regulated and filtered 12 volt power is supplied to the cameras from this unit. The camera controller is housed in an environmentally sealed, water-tight aluminum case and fitted with waterproof connectors. (Figures 13.2.7-1 and 2) Two configurations of this unit are available for in cab mounting. One configuration is designed to accept bulkhead connectors (Figures 13.2.7-3 and 4) mounted through the vehicle cab wall (Figure 13.2.7-5).

Series 200 Camera Controller Specifications

Physical Dimensions:	*8.6" x 4.7" x 3.6"*
Weight:	*5.6 lbs*
Vibration Resistance:	*7G (11 Hz to 200 Hz)*
Shock Resistance:	*70G (non-repetitive)*
Operating Temperature:	*-20 to +50 degrees C*
Environmental:	*watertight*
Power Consumption:	*150 watts (with heater)*
Power In:	*24 volts 5.5 amps (max)*

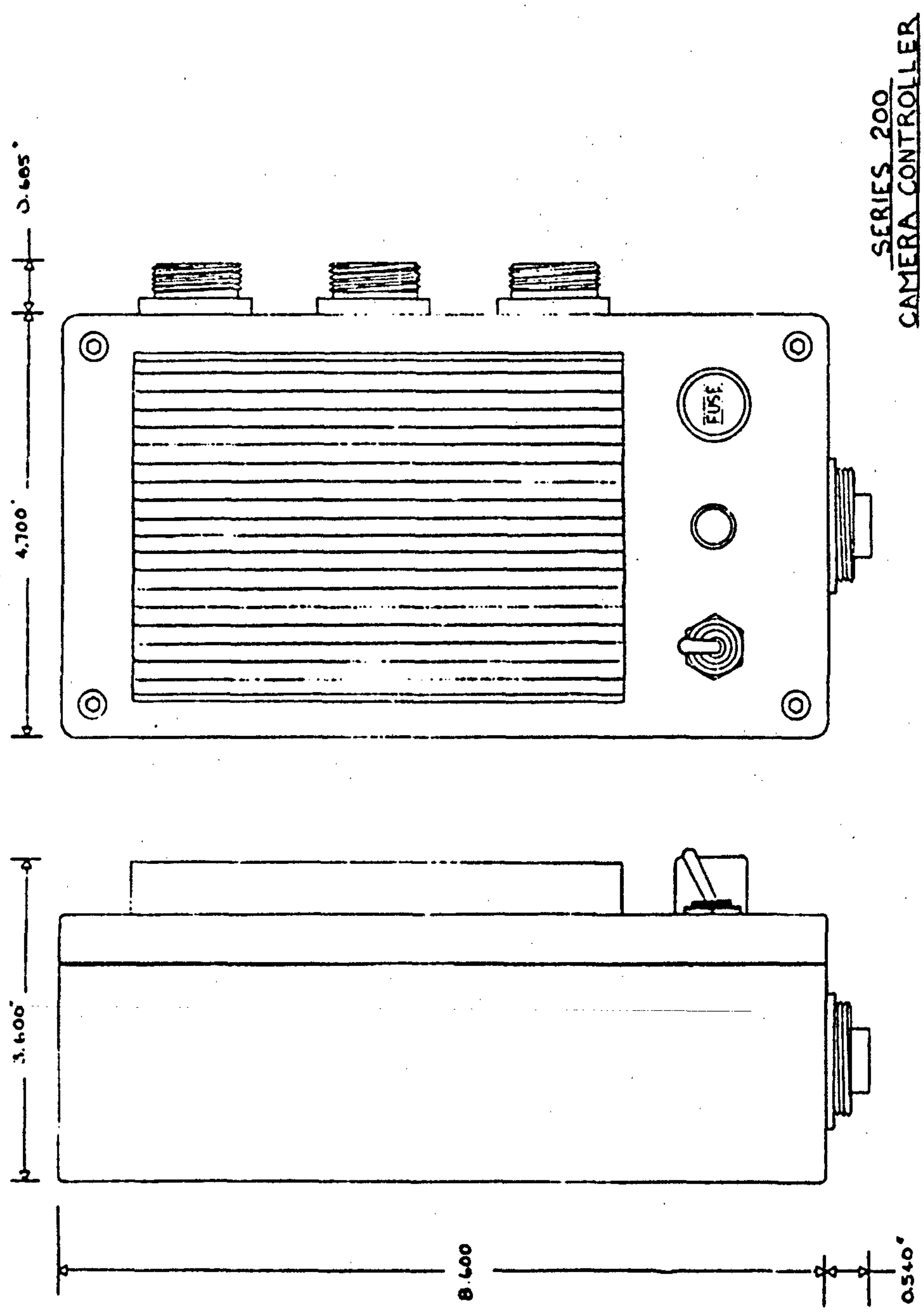


Figure 13.2.7-1 Series 200 Camera Controller

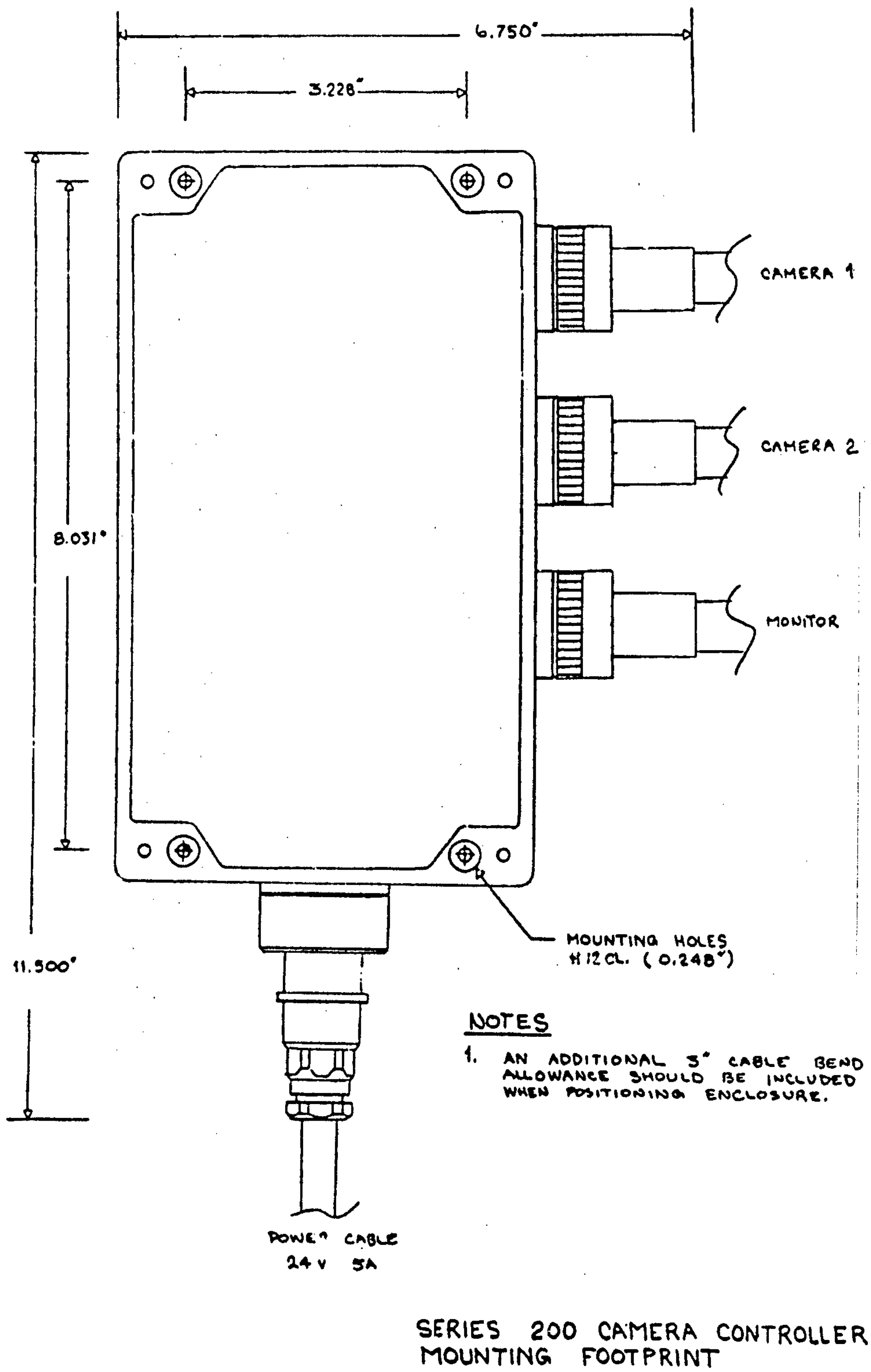


Figure 13.2.7-2 Series 200 Camera Controller Mounting Footprint

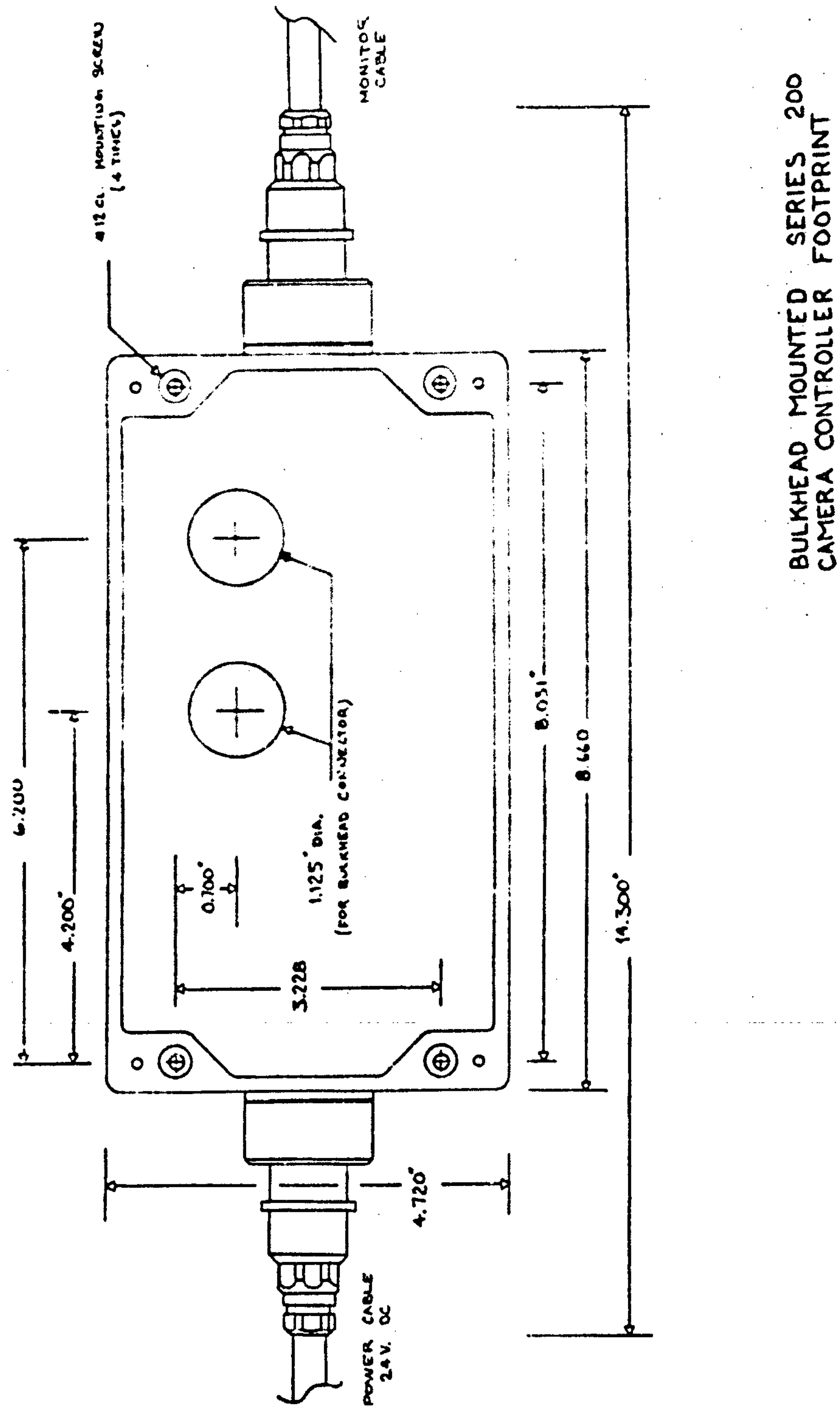


Figure 13.2.7-3 Bulkhead Mounted Series 200 Camera Controller Footprint

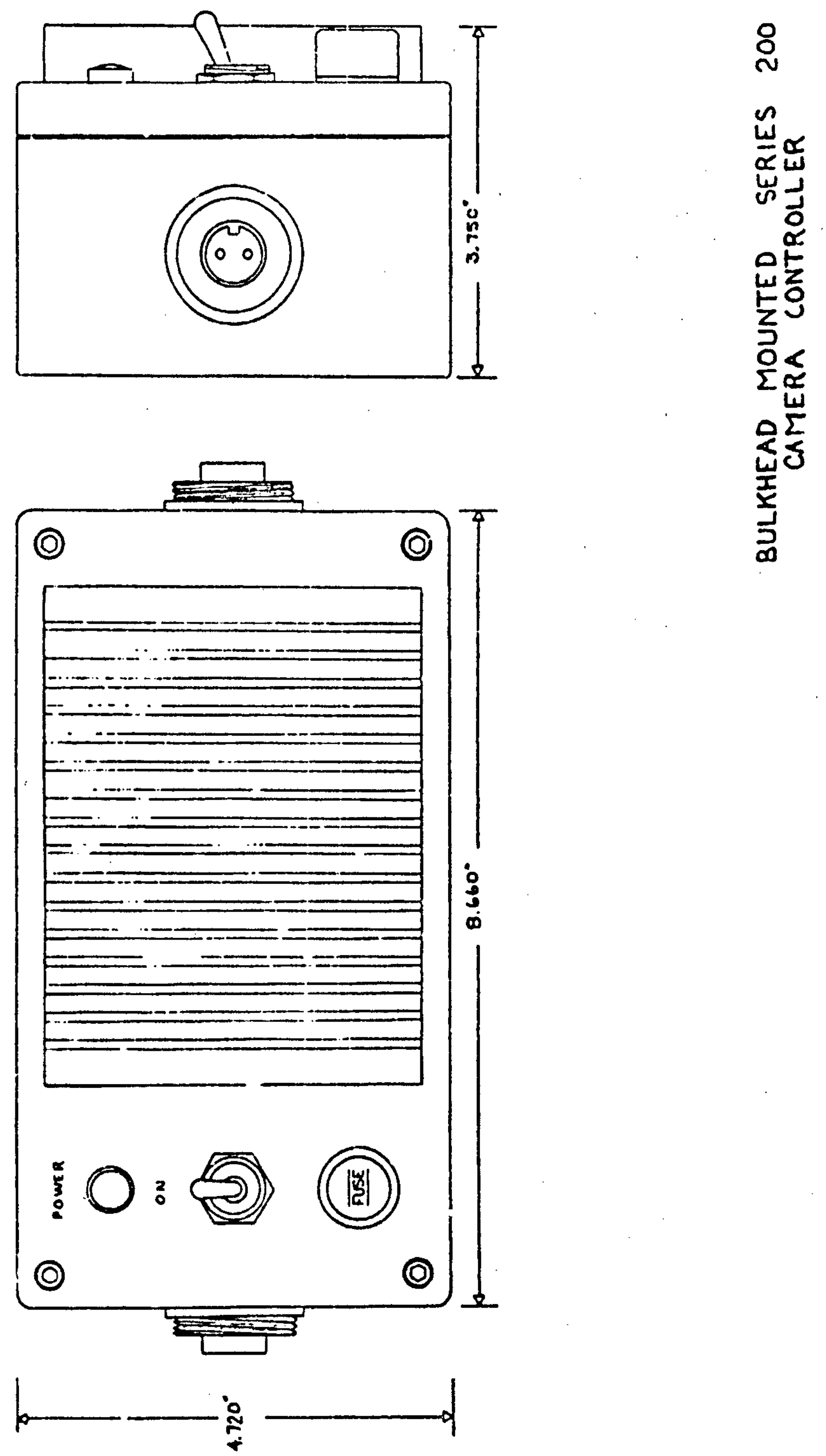


Figure 13.2.7-4 Bulkhead Mounted Series 200 Camera Controller

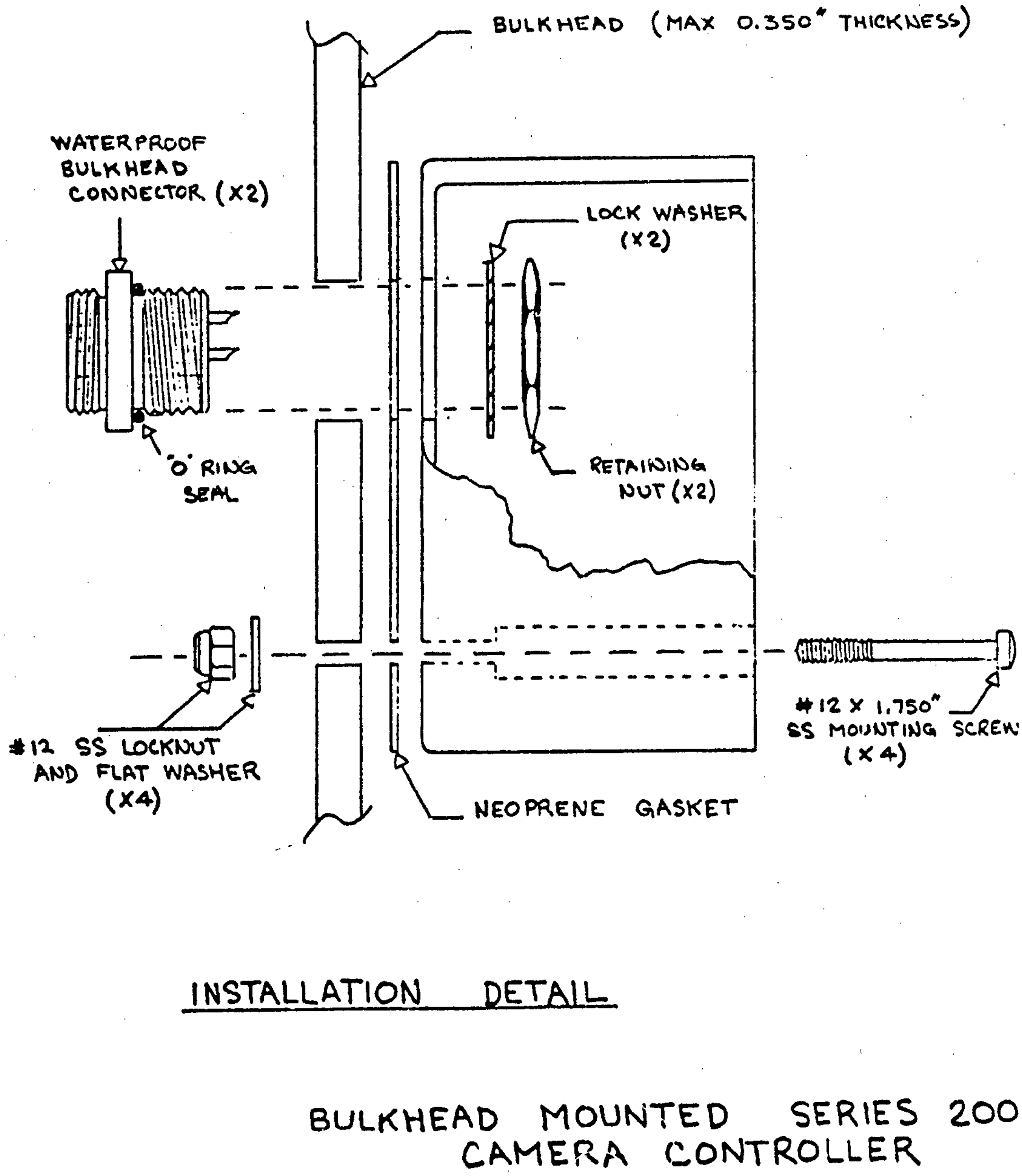


Figure 13.2.7-5 Installation Detail For Bulkhead Mounted Series 200 Camera Controller

13.3 Performance.

Implementation of the CCTV system is not expected to impact ATLAS performance.

13.4 HFE/Safety.

Implementation of the CCTV system is central to the safe and reliable operation of ATLAS. Supplemental vision is required to assist the operator in locating and engaging a load in a darkened environment, i.e., an ISO container. Subsequently, the operator is required to negotiate the vehicle in reverse with the load until clear of the ISO container; the rear vision system will permit the operator to assure that the intended path is clear of personnel and materials.

The CCTV system is projected to have a duty cycle of 3-5%.

13.5 Reliability.

Subsystem reliability allocation for the CCTV system is MTBF=3000 hours.

13.6 Producibility.

Implementation of the CCTV system will not compromise the producibility of ATLAS.

13.7 Cost Impact.

Implementation of the ATLAS CCTV system has substantial impact on procurement costs. The estimated cost increase is $10,000. Improvements in electronic technology are constantly reducing maintenance and support costs.

13.8 Integrated Logistic Support.

The CCTV system is modular in design. It is anticipated that repair by replacement of modules will by appropriate. It may be desirable to conduct a repair versus discard analysis when developing the maintenance philosophy for this system. The reliability and availability of the system is good. Most of the CCTV components will be externally mounted, aiding in maintainability. The proper protection of the cameras is a minor reliability concern to be addressed.

Attachment 1
Corrosion Resistant Coating Technology

1.0 Corrosion Resistant Coating.

A corrosion resistant coating has been identified with a corrosion resistance capability that substantially mitigates the corrosion associated with the extensive operation in the surf zone required by ATLAS.

Implementation of this coating technology precludes from further consideration the use of exotic materials (stainless steels) and processes (plating) and minimizes procurement and life cycle costs. The coating technology provides the desired corrosion protection at a fraction of the cost of alternate materials and processes. Implementation of the coating technology will avoid a 40% to 50% increase in procurement costs, 10% to 15% reduction in development costs, and a 15% to 30% reduction in owning and operating costs.

1.1 Discriminator. The primer incorporates an extraordinary, zinc-dust, rich primer similar to MIL-P-26195 with an epoxy polyamide base similar to MIL-P-53022 to provide corrosion resistance in excess of 1000 hours per ASTM B117. Limited testing has been conducted up to 1500 hours.

1.2 Compatibility - CARC Paint. This primer is compatible with a MIL-A-46168 top coat. Alternate primers, compatible with CARC topcoats, do not provide the desired level of protection. Alternate primers that provide the corrosion resistance are not compatible with CARC topcoates. CARC provides a top coat of a material with high molecular density that may be decontaminated after being subjected to chemical, biological, and nuclear warfare agents. The principal decontaminant is MIL-D-50030H Military Specification for Decontamination Agent, DS2.

2.0 Application.

The CARC topcoat will eliminate contact between the salt water and the zinc-rich primer, hence the primer will not experience corrosion. At such time that the top-coat is violated, the zinc primer will begin to corrode (general corrosion) in the presence of salt water. After the primer is violated and the steel base metal is exposed to the salt water, a galvanic cell is established with the zinc primer corroding preferentially to the steel base metal.

The zinc-rich primer provides a sacrificial material that will corrode preferentially to steel (and other materials) in the presence of salt water. As a result of this preferential corrosion, the corrosion of the base material will be minimized.

The corrosion rate for the zinc rich coating will be greater than the corrosion rate for the steel substrate, hence the corrosion damage will be limited largely to the sacrificial coating. The corrosion by-products of the zinc may be readily identified visually. Corrosion of the steel substrate will occur only after the sacrificial coating has been depleted.

Upon identification by visual inspection, the corroded area may be cleaned and recoated with the zinc rich primer and topcoat thus preventing any substantial damage to the component.

2.1 Corrosion Resistance, Zinc. The corrosion resistance of zinc in salt water is influenced by the amounts of dissolved salts, principally chlorides and sulfates, in the water. The high chloride content of salt water (representative of the salt spray test) would normally accelerate the corrosion rate, but the presence of magnesium and calcium ions retards the corrosion rate.

The effect of time of exposure on the corrosion rate in natural waters indicates that the corrosion rate in seawater exceeds that of freshwater, but after a period of two years the rate of corrosion in salt water decreases to approximately the rate of fresh water.

2.2 Corrosion Protection. The corrosion resistance of zinc compares very favorable with other coating materials when immersed in saltwater. Side-by-side evaluations conducted with aluminum-, cadmium-, lead-, tin-, and zinc-coated specimens resulted in failure of all coatings within 2 years except for the zinc coated specimens which were evaluated for an additional 4 years. After 6 years of immersion, the coatings were just ceasing to provide complete protection. The zinc coating was consumed at a rate of 0.5 ounces-year/ft^2.

Typically, zinc coating would not be employed alone to provide the necessary protection for marine structures, but would be employed in conjunction with other protective measures. With respect to ATLAS, the zinc rich primer is recommended in combination with a top coat of CARC paint that minimizes the exposure of the primer and base metal to the corrosive environment.

2.3 Noble Coating. Noble coatings are an option for general protection of the ATLAS structure. Noble coating such as chrome, cadmium, etc, exhibit a corrosion rate less than steel in salt water. At such time that the coating is violated and the steel substrate and coating are exposed to salt water, a galvanic cell is formed. At that time, the steel will corrode preferentially resulting in substantial pitting/corrosion damage to the substrate. The corrosion rate (damage rate) is accelerated by the relatively large cross section of the coated area as compared to the very small cross sectional area of the exposed substrate.

3.0 Processing.

The processing requirements are consistent with the processing of MIL-A-46168 coating including preparation of the base material, application of the primer, and application of the top coat though several considerations exist. The dry film coating thickness is limited to 20 mils to provide for field repair of the coating by US Army personnel.

3.1 Base Metal Preparation. The base (ferrous) material must be grit blasted to a white or near white condition as defined by the National Association of Corrosion Engineers (NACE). The base material may then be subjected to a conversion coating of either zinc or iron.

3.2 Primer Application. The primer requires a longer cure under all temperature and humidity conditions than comparable MIL-P-26195 and MIL-A-46168 coatings. Various combinations of lower temperatures and higher humidity will retard curing until more favorable atmospheric conditions exist or until the product is subjected to a forced cure. Curing will be completed between 24-72 hours under common atmospheric conditions.

3.3 Top Coat Application. The top coat should be applied within 2 weeks after the primer has cured in order to provide the desired intercoat adhesion. At such time that this span of time is exceeded, an intermediate (epoxy polyamid) primer of approximately 3.0 mils (Dry Film Thickness (DFT)) thickness) is required to wet the previously primed and cured primer surface of the part. The top coat may then be applied without loss of intercoat adhesion. The coating may be subjected to a scribe test after 72 hours to determine the acceptability of the adhesion of the coating to the base material.

4.0 E-Deposition Coating.

Electrolytic deposition (E-coats or E-deposition) may be considered in lieu of the zinc rich primer. Technical direction was provided to consider E-coats to address crevice corrosion. E-depostion coatings will coat crevices inaccessible to normal spray paint processes. Unfortunately, E-coat primers are not compatible with CARC topcoats. E-coat primers also possess the following shortcomings:

a) *E-Deposition painting system typically costs in excess of $1,000,000 for a new installation and is not generally available within the construction equipment industry.*

b) *Base metal must be exceedingly clean to provide the desired coat incorporating a 7-stage process for mill scaled metal, metal with welding slag, cast/forged surfaces, etc. (near white blast, wash, rinse, conversion coat, rinse (de-ionized water), prime. (Residual oxides and contamination left on the surface of the part (in particular crevices) disrupts the flow of the electrical current causing imperfections within the paint.)*

c) *Top coat should be applied within 30 days. After 30 days, the part will require a MIL-P-53022 primer to obtain the necessary intercoat adhesion. (Primers typically have very good wetting capabilities.)*

d) *Primer degrades rapidly in sunlight (under-roof stowage only)*

e) *Previously painted surfaces must be thoroughly cleaned (high-pressure, hot alkaline spray or steam clean) prior to CARC topcoat.*

5.0 Material Considerations.

A number of supplemental material considerations identified in this paragraph must be addressed with maturation of ATLAS.

5.1 Environmental Considerations. Two considerations have been identified at this time that will significantly impact the cost of providing the desired corrosion resistance. The cost impact will be influenced by a number of factors such as current equipment, location of the manufacturing facility, EPA legislation, etc.

5.1.1 Hazardous Material. Zinc (as are most metals) is considered a hazardous material; hence, the waste water, filters, cleaning fluids, etc. shall be treated as hazardous waste. Dry-filter paint booths are recommended. Treatment of waste water may preclude consideration for water wash paint booths in particular if a number of paint booths share a common water reservoir.

5.1.2 Volatile Organic Content (VOC). The primer has a volatile organic content of 3.64 lbs/gallon which exceed federal guidelines of 3.5 lbs/gallon. The VOC (the measure of a material to air pollution) may become a major processing consideration depending upon the local and regional air pollution board and, to a lesser extent, on state and/or federal clean air mandates. Reductions in the VOC content are being addressed by the paint manufacturer.

5.2 Usage. The rough terrain fork lift will require approximately 5 gallons of primer and topcoat. Each weighs approximately 18 lbs/gal.

5.3 Scribe Test. The scribe test provides a destructive, pass-fail in-process method for assessing the primer and intercoat adhesion.

The scribe test should be run between 24 and 72 hours after the top coat has been applied by a trained, quality control technician. The scribe shall provide a very sharp knife edge. The technician will provide a simple cross-hatch pattern with an intersection of nominally 60 degrees with the scribe maintained perpendicular to the surface. The scribe mark introduces a defect through the thickness of the coating. Subsequently the technician will apply a scribe tape and upon removal of the tape determine the acceptability of the adherence of the coating.

Some government agencies required a cross-hatch pattern at an intersection of 90 degrees. In either situation, failure of the coating is defined as the loss of 2 or more squares.

5.4 Aluminum. Pretreatments, MIL-A-8625 (Anodizations) or MIL-C-5541 (Chemical Conversion), are recommended for aluminum alloys followed by a wash primer per DOD-P-15328 (typically TT-C-490 Type III) with a MIL-P-53022 primer and MIL-C-46168 top coat.

5.5 Plastic/Rubber. The compatibility of plastic or rubber with the coating must be established to minimize or preclude degradation of the mechanical properties of the base material. The primary consideration for determining the retention of the coating will be the movement of the plastic or rubber parts.

Though plastics and rubbers may be coated, those components that are subjected to large deflections, eg. boots, hydraulic hoses, engine/cab mounts, etc., will spall the coating with time. Simply the CARC coatings are stiffer and relatively brittle compared to the non-metallic plastic/rubber component. The difference in relative stiffness of the two materials introduces shear stresses at the interface that cause the spalling of the top coat.

Attachment 2
Surf Zone Stability

1.0 Introduction.

The ATLAS rough terrain fork lift is required to negotiate a surf zone during a LOTS operation. Exiting the surf zone ladened with a 10,000 lb. payload carried at heights of 18 and 60 inches exposes the rear of the vehicle to a wave which may tip the vehicle forward.

A simple (quick-look) 2-dimensional analysis was initiated to investigate this operational scenario. The tipping load for this analysis is defined as the wave loading required to cause momentary loss of contact between the tire and the ground. Three loading conditions have been investigated; the 10,000 lb load carried at 60 inches may be compared to each an unloaded condition with the forks at 60 inches and the same 10,000 lb load carried at 18 inches. Three loading conditions have been investigated:

a) 10,000 load carried at 60 inches;
b) Unloaded with the forks at 60 inches, and;
c) 10,000 load carried at 18 inches.

1.1 Results. ATLAS stability is not compromised when operating in a surf zone. Figure 1.1-1 summarizes the results of this analysis. Substantial wave force (>10000 lbs) and duration (≈1 second) is required to tip the ladened vehicle with the load at 60 inches.

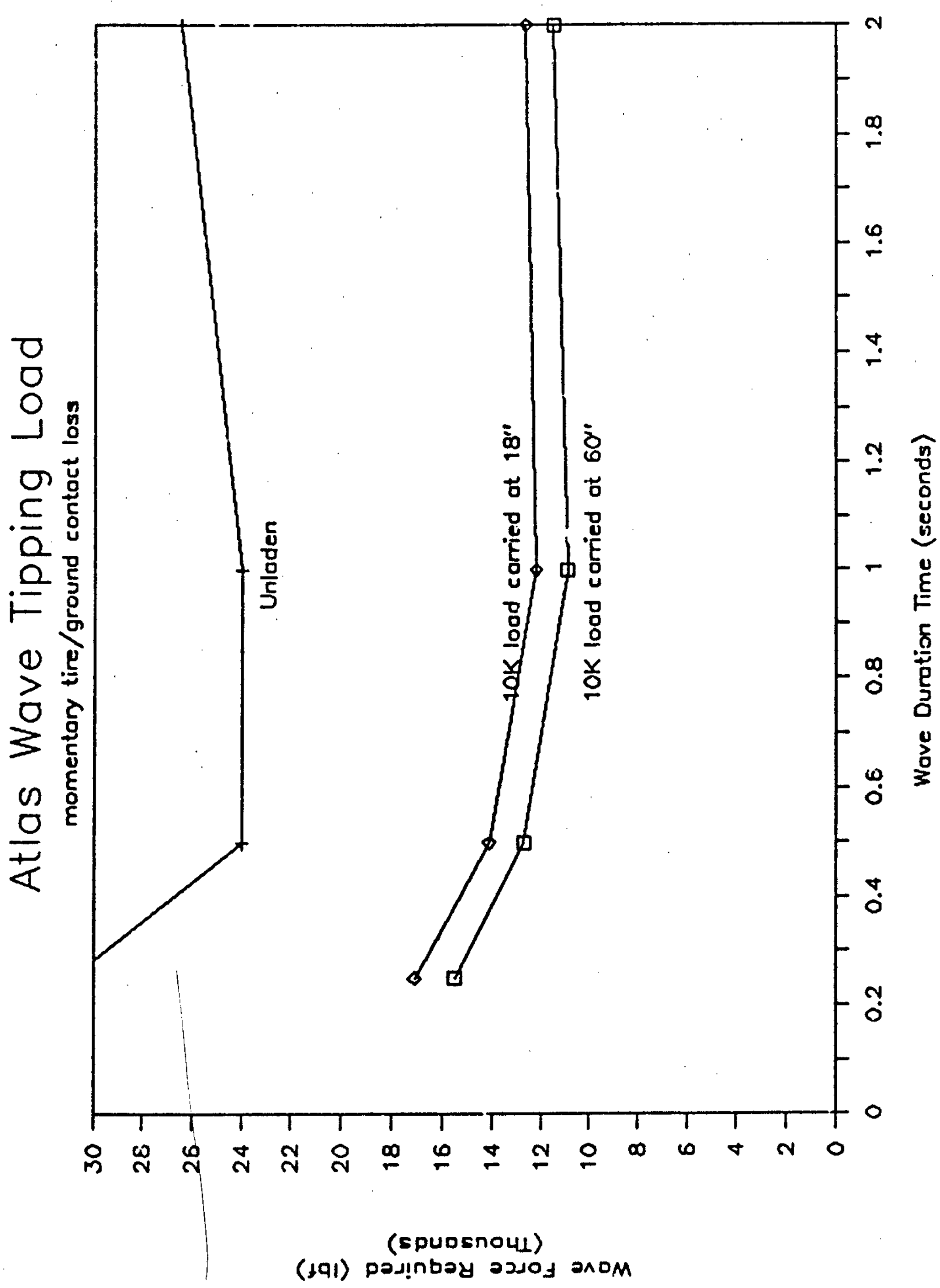


Figure 1.1-1 ATLAS Surf Zone Stability Summary

1.2 Recommendation. The ATLAS is sufficiently stable under the conditions assessed hence no additional analysis is required at this time. With maturation of the program, the government should review the configuration of ATLAS and anticipated LOTS operational scenarics with respect to this analysis and determine the need for additional analysis.

1.3 Operational Considerations. For purposes of this evaluation, the vehicle was assumed to be operating in a V-shaped bay where a wave would build as it progressed into the bay and break over exposed beach. The vehicle with the suspension system locked out is assumed to be operating on level grade (as opposed to a more naturally occuring positive grade). More importantly, the vehicle is modeled out of the water yet impacted at by a wave at the rear of the vehicle. Positive or negative effects of buoyancy are offset with respect to each other.

2.0 Model Development.

The ATLAS vehicle model was assembled to address the concern of waves impacting the vehicle while in the surf. The simple 2D dynamic vehicle model consists of a rigid-body (vehicle with and without payload) with vertical and fore-aft springs (tires).

2.1 Wave Loading. The wave loading is applied in a horizontal direction to the rear of the vehicle over a period of time. This loading function is represented by the positive half of one cycle of a sine wave function. The duration of the loading function was varied from 0.25 to 2.0 seconds.

2.2 Tipping Load. The tipping load is defined to be the load required to cause momentary tire/ground contact loss.

2.3 Assumptions. The simple analysis makes several assumptions which tend to give a more conservative result than a more complex analysis would provide. The major assumptions include;

a) the vehicle is traveling on level ground,
b) the wave impact force acts horizontally,
c) the beneficial damping provided by water enveloping the vehicle is ignored (only tire damping is included),
d) the vertical component (secondary loading) of the wave loading and vehicle reaction are assumed to offset each other.
e) the damping of the beach sand is ignored.

2.4 Tire Stiffness. The ratio of fore-aft/vertical tire stiffness was decreased as the wave loading time increased, simulating the loading rate sensitivity of the tires. As the loading rate increases the tires will exhibit a less compliant or stiffer response, i.e. the loading rate is inversely related to loading time.

Dynamic Spring Rate and Dampening data was provided by the Goodyear Technical Center for this evaluation (Figures 2.4-1 and 2.4-2).

For purposes of this evaluation, tire stiffness of 4600 lbf/in. represented the application of the 17.5R25 and 20.5R25 tires at 50 and 40 psi tire pressure respectively. All four tires of the vehicle are the same and pressured equally.

DYNAMIC SPRING RATE AND DAMPING

RADIAL TIRE: 17.5R25 RL-2F L-2

SPEED (MPH)	PRESSURE (PSI)	LOAD (LB)	DAMPING FACTOR (%)	DAMPING COEFFICIENT (LB-SEC/IN)	FREQUENCY (HZ)	SPRING RATE (LB/IN)
5	50	13400	1.85	14.4	1.88	4600
10	50	13400	1.24	9.6	1.87	4560
20	50	13400	1.10	8.5	1.87	4560
5	75	15600	1.67	16.2	2.00	6110
10	75	15600	1.13	11.0	2.00	6110
20	75	15600	0.62	6.0	2.00	6110

Figure 2.4-1

DYNAMIC SPRING RATE AND DAMPING

RADIAL TIRE: 20.5R25 RL-2F L-2

SPEED (MPH)	PRESSURE (PSI)	LOAD (LB)	DAMPING FACTOR (%)	DAMPING COEFFICIENT (LB-SEC/IN)	FREQUENCY (HZ)	SPRING RATE (LB/IN)
5	40	15700	1.93	16.3	1.73	4600
10	40	15700	1.26	10.6	1.71	4500
20	40	15700	1.22	10.2	1.71	4500
5	75	20900	1.80	22.1	1.86	7160
10	75	20900	1.15	14.1	1.86	7160
20	75	20900	1.19	14.6	1.86	7160

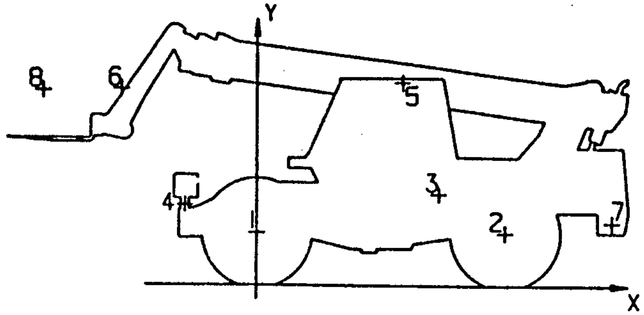
Figure 2.4-2

2.5 Vehicle Speed. Vehicle speed was assumed to be 5 mph.

2.6 Vehicle Data. Coordinates are referenced with respect to the ground line at front axle. The positive X axis is pointing to the rear of the vehicle. Figure 2.6-1 provides Center of Gravity and Mass Moment of Inertia data used for this analysis and summarized in Table 1.

	Vehicle Weight (lbf)	*Center of Gravity X*	*Center of Gravity Y*	*Tire Stiffness lbf/in*	*Tire Damping lbf/(in/sec)*	*Wave Impact Height (ft)*
Unladen	*32,250*	*5.95*	*4.75*	*4600*	*14.4*	*3.75*
Laden(60)	*42,250*	*2.41*	*5.55*	*4600*	*14.4*	*3.75*
Laden(18)	*42,250*	*2.41*	*4.72*	*4600*	*14.4*	*3.75*

Table 1. Model Inputs



CENTRES OF GRAVITY- UNLADEN CONDITION

		W	X	WxX	Y	WxY
1	FRONT AXLE	2600	0.00	0	2.17	5642
2	REAR AXLE	2600	10.75	27950	2.17	5642
3	CARRIER	14100	7.70	108570	4.00	56400
4	OUTRIGGERS	2200	-3.10	-6820	3.40	7480
5	BOOM	6600	6.15	40590	8.50	56100
6	HEAD	1950	-5.80	-11310	8.20	15990
7	BALLAST	2200	14.92	32824	2.70	5940
		Σ32250		Σ191804		Σ153194

$\bar{X}=5.95$ ft $\bar{Y}=4.75$ ft

CENTRES OF GRAVITY- LADEN CONDITION

		W	X	WxX	Y	WxY
	UNLADEN	32250		191804		153194
8	LOAD	10000	-9.00	-90000	8.13	81300
		Σ42250		Σ101804		Σ234494

$\bar{X}=2.41$ ft $\bar{Y}=5.55$ ft

MASS MOMENT OF INERTIA- UNLADEN CONDITION

		W	X^2	WxX^2	Y^2	WxY^2
1	FRONT AXLE	2600	0.00	0	4.71	12246
2	REAR AXLE	2600	115.6	300560	4.71	12246
3	CARRIER	14100	59.3	836130	16.00	225600
4	OUTRIGGERS	2200	9.6	21120	11.56	25432
5	BOOM	6600	37.8	249480	72.25	476850
6	HEAD	1950	33.6	65520	67.24	131118
7	BALLAST	2200	222.6	489734	7.29	16038
		Σ32250		Σ1962544		Σ899530

MASS MOMENT OF INERTIA- LADEN CONDITION

		W	X^2	WxX^2	Y^2	WxY^2
	UNLADEN	32250		1962544		899530
8	LOAD	10000	81	810000	66.10	660969
		Σ42250		Σ2772544		Σ1560499

REFERRING TO CENTRE OF GRAVITY

UNLADEN CONDITION

$$1962544 = I_{cg} + (32250 \times 5.95^2)$$

$$I_{cg,x} = 820813 \text{ lbft}^2$$

$$899530 = I_{cg} + (32250 \times 4.75^2)$$

$$I_{cg,y} = 171889 \text{ lbft}^2$$

LADEN CONDITION

$$2772544 = I_{cg} + (42250 \times 2.41^2)$$

$$I_{cg,x} = 2527151 \text{ lbft}^2$$

$$1560499 = I_{cg} + (42250 \times 5.55^2)$$

$$I_{cg,y} = 259093 \text{ lbft}^2$$

ATLAS	UNITS-lb & ft	A MOORE	30/10/91
CALCS FOR POSITION OF C OF G AND MASS MOMENTS OF INERTIA WITH FORKS ABOVE WATER.			

Figure 2.6-1 Center of Gravity and Mass Moment of Inertia Data

2.7 Analysis of Results. The tipping load for this analysis was defined to be the load required to cause momentary tire/ground contact loss. Due to the inherent stability of the vehicle, these loads are not substantial enough to completely overturn the vehicle. However, under these loading conditions, the operator may experience a momentary loss of steering of the vehicle as the tires lose contact with the ground. Wave loading required to tip the vehicle is marginally reduced when the load is carried at a height of 60 inches as opposed to 18 inches (Reference Figure 1.1-1).

The timeplots (Figures 2.7-1-12) included show the vehicle response has not settled out after 10 seconds inferring that the vehicle may be sensitive to a second wave load. Operationally, the vehicle would not be expected to operate in the surf zone exceeding the period defined by the frequency of the waves.

This continuing response is due to the low damping rates for the tires alone. If the damping effects of the water and sand on the vehicle were considered, this vibration would decay much more rapidly.

This simple analysis provides a conservative estimate of the horizontal wave force required to tip the vehicle. The overall minimum wave force required to cause any tire/ground contact loss was over 10,000 lbf.

Wave Impact	*Fore-Aft/Vertical*	*Tipping Loads (lbf)*		
Time (sec)	*Tire Stiffness*	*Unladen (60")*	*Laden (60")*	*Laden (18")*
0.25	*1.0*	*31,000*	*15,500*	*17,500*
0.50	*0.5*	*24,000*	*12,700*	*14,500*
1.00	*0.25*	*24,000*	*10,900*	*12,500*
2.00	*0.1*	*26,500*	*11,500*	*13,000*

Table 2. Analysis Runs and Results

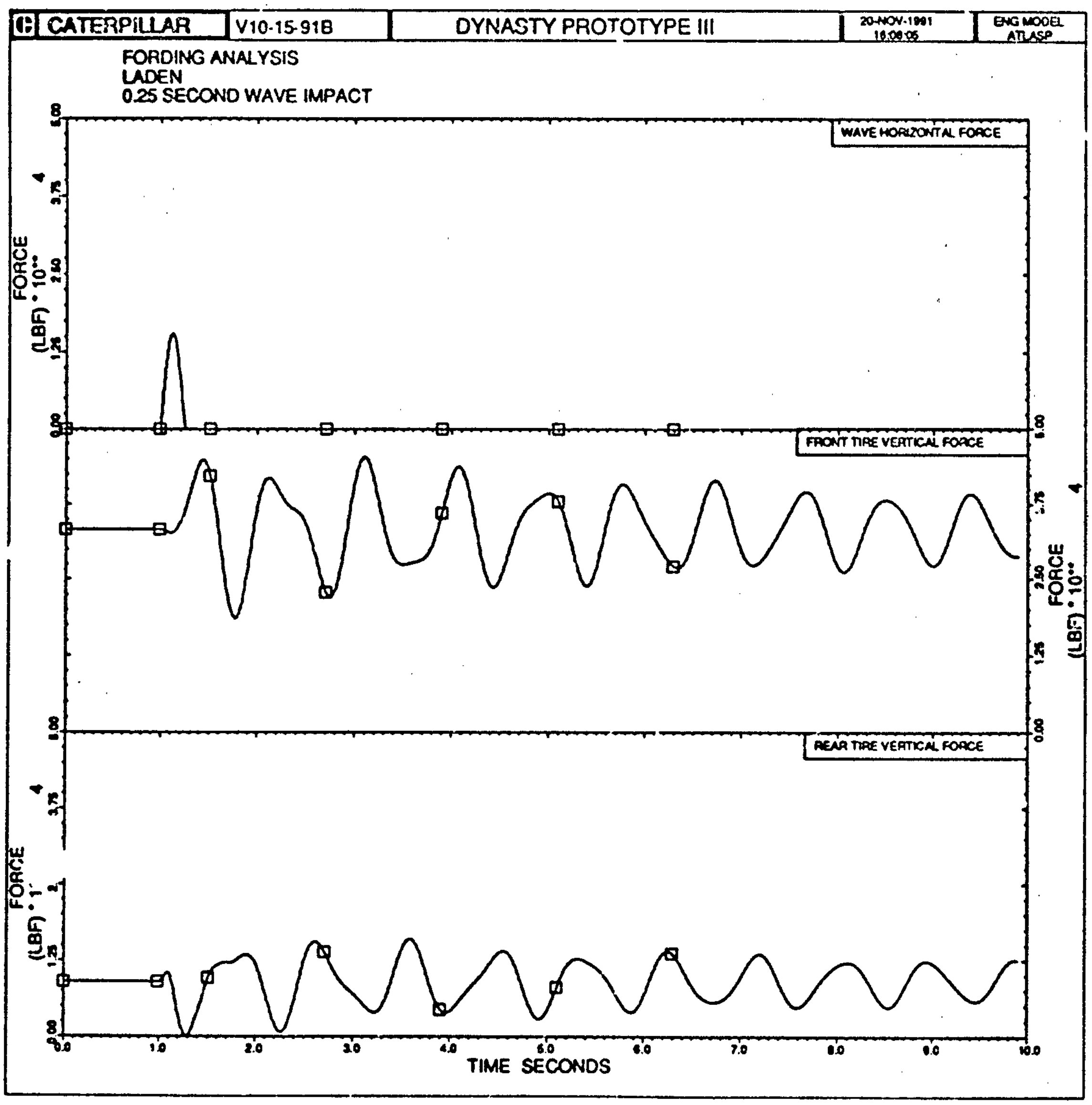


Figure 2.7-1 ATLAS Loaded, Load at 60" Height, 0.25 Second Wave Impact

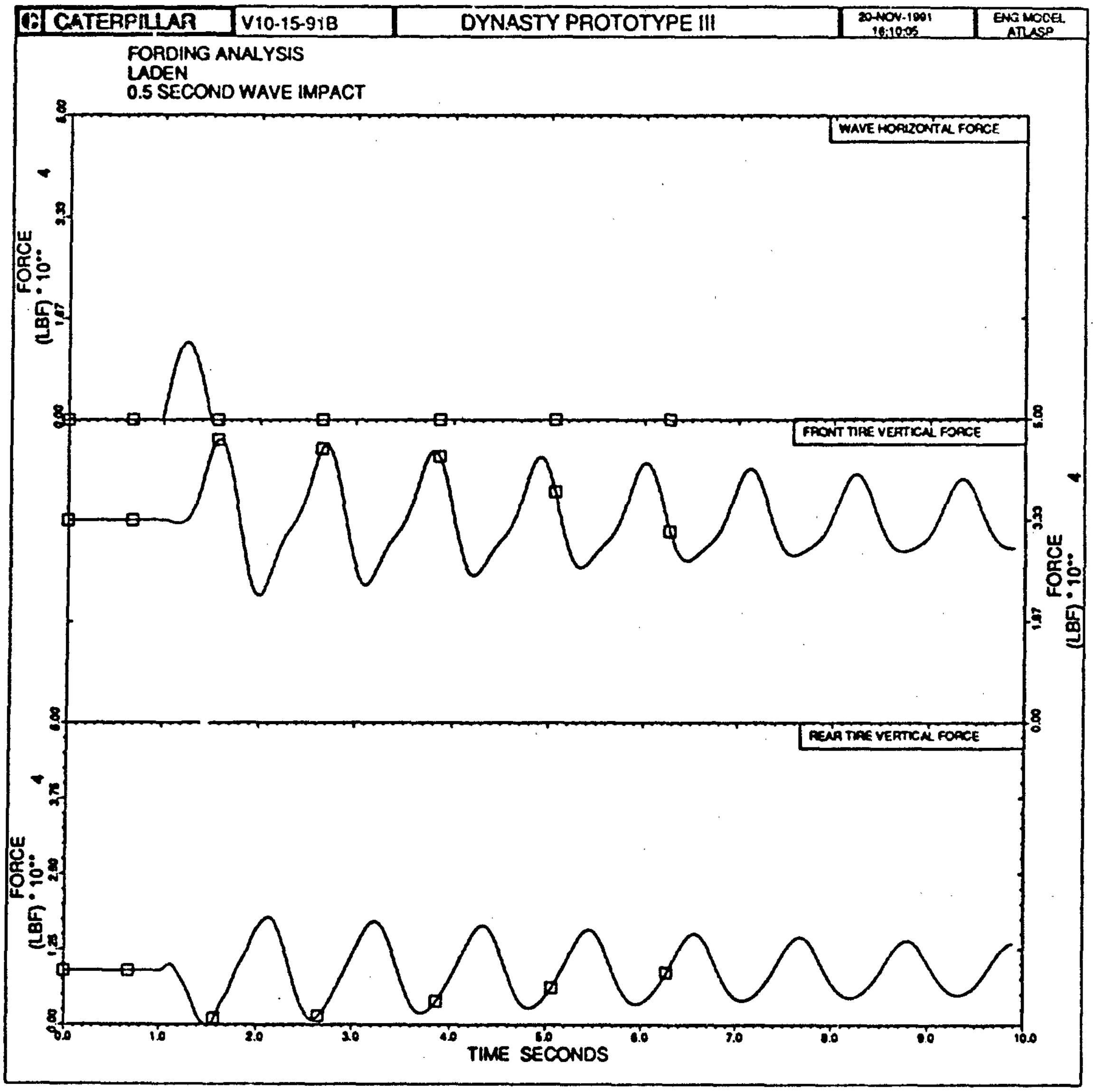


Figure 2.7-2 ATLAS Loaded, Load at 60" Height, 0.5 Second Wave Impact

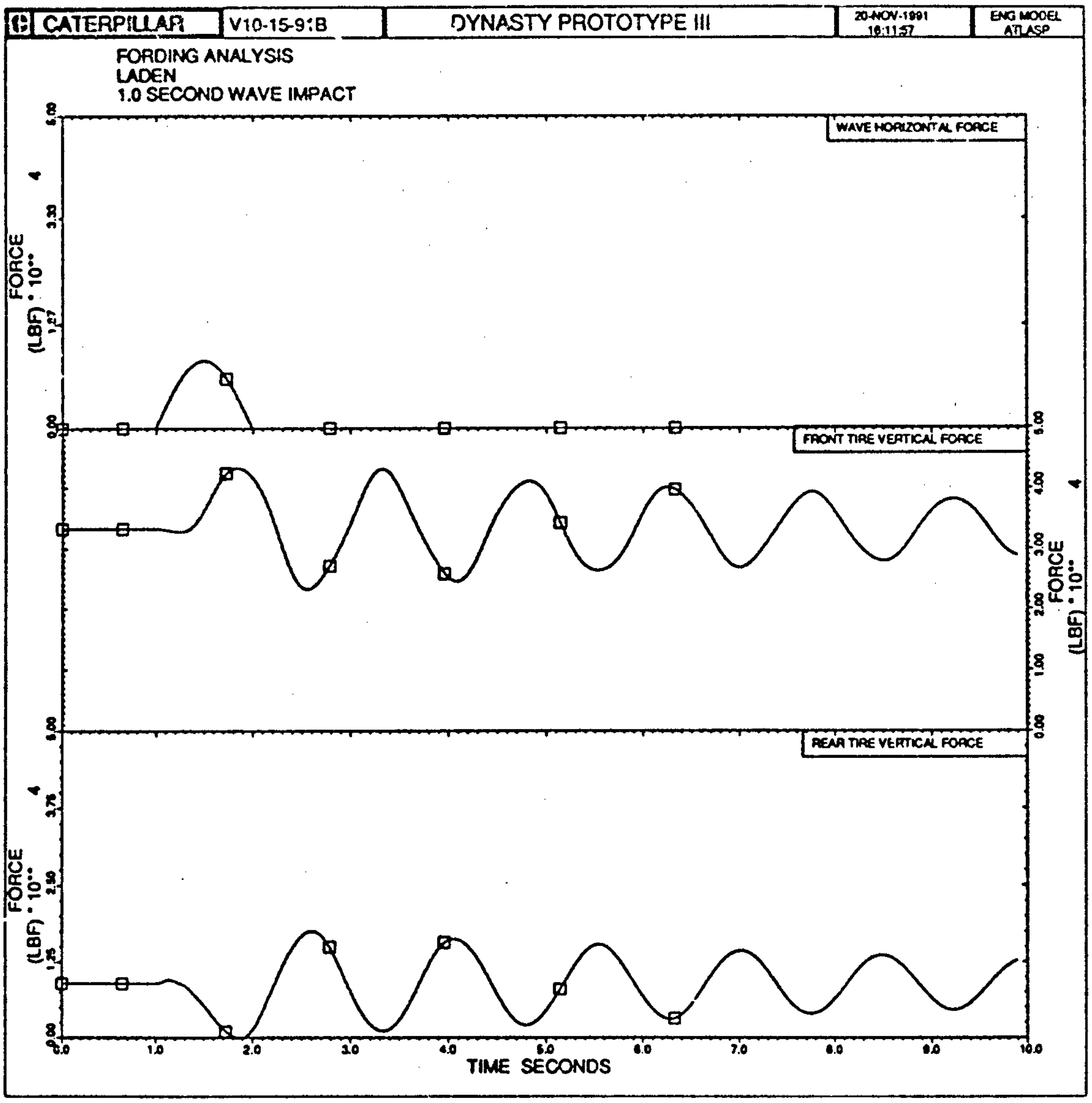


Figure 2.7-3 ATLAS Loaded, Load at 60" Height, 1.0 Second Wave Impact

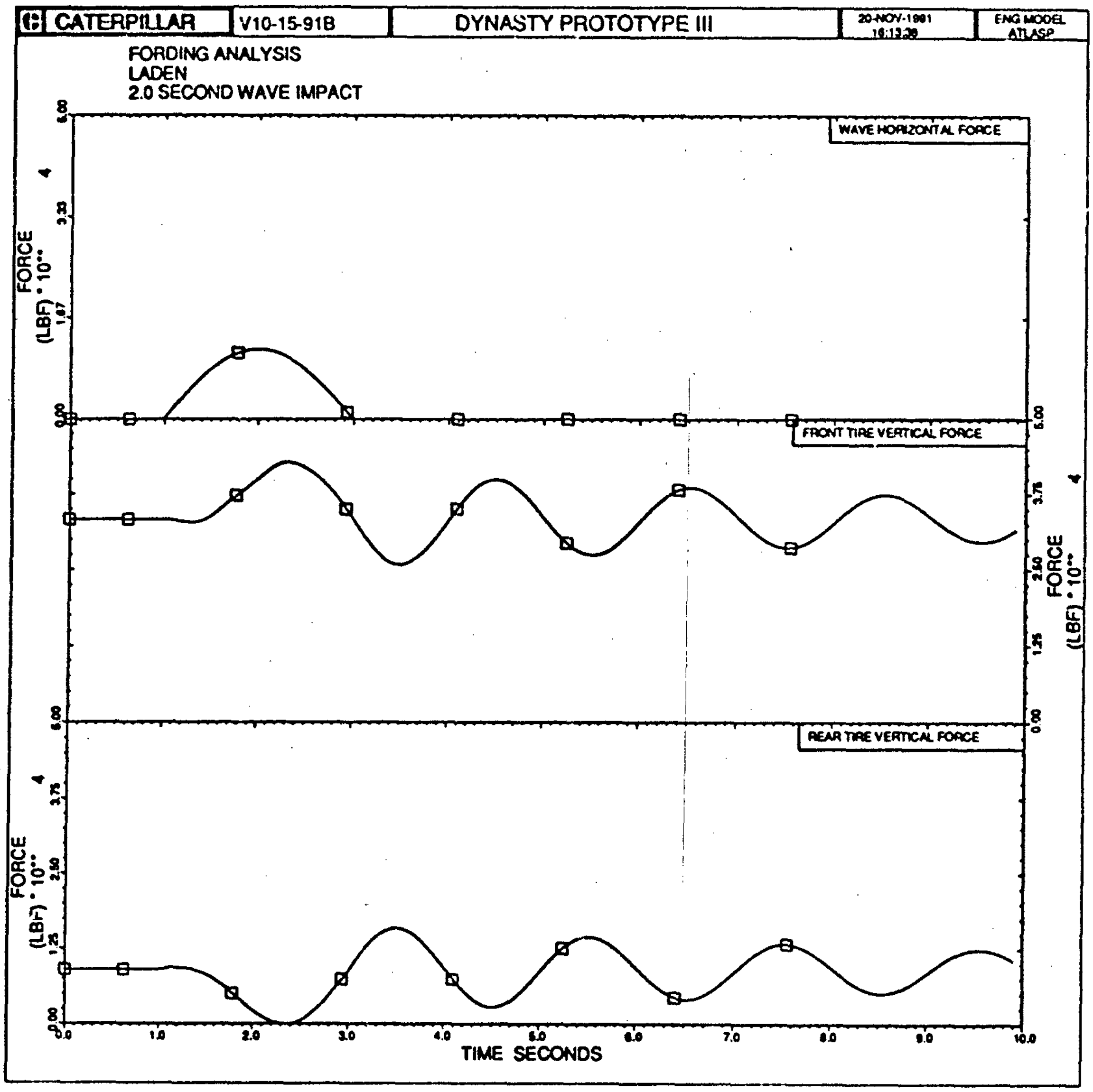


Figure 2.7-4 ATLAS Loaded, Load at 60" Height, 2.0 Second Wave Impact

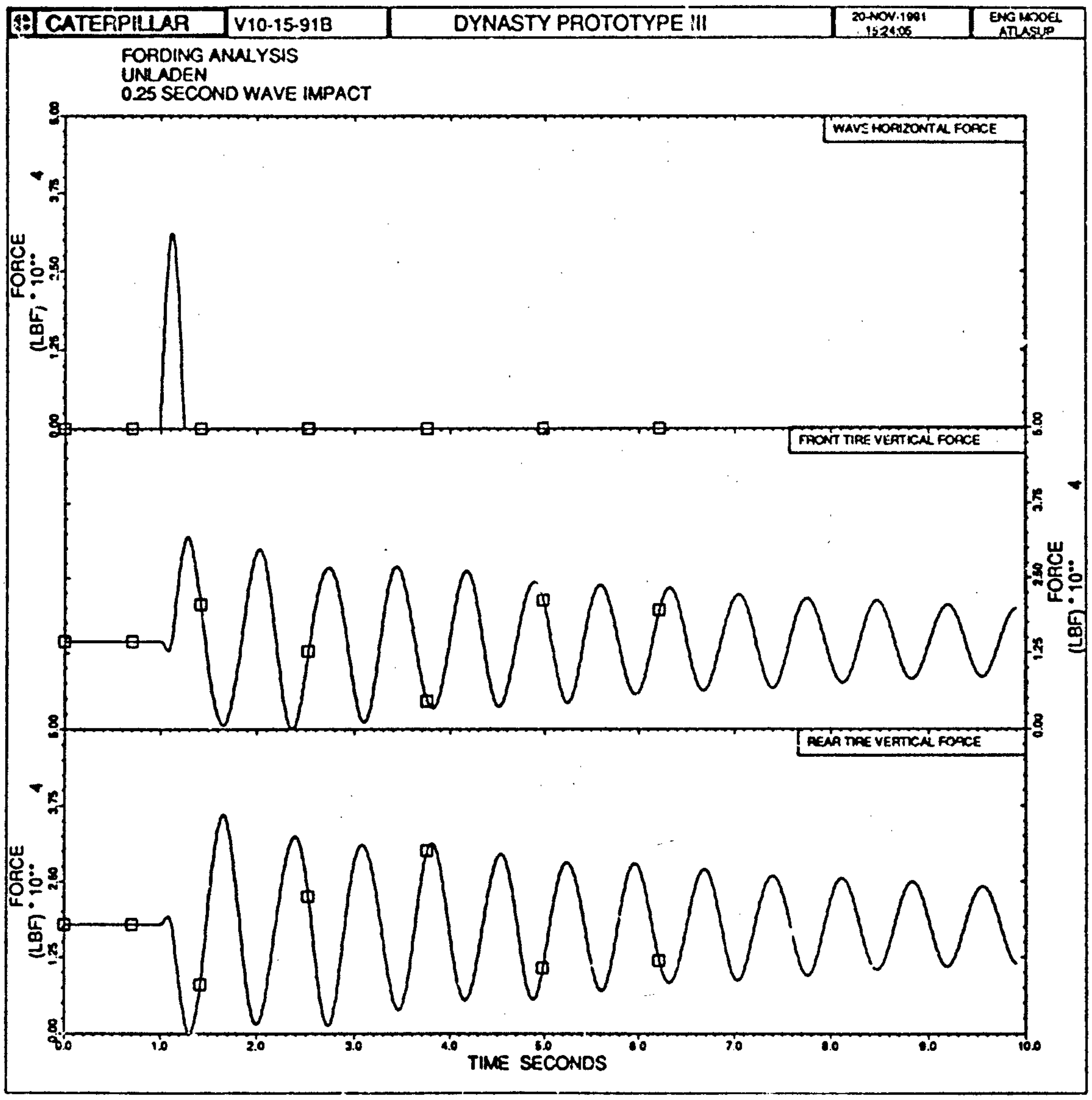


Figure 2.7-5 ATLAS Unloaded, 0.25 Second Wave Impact

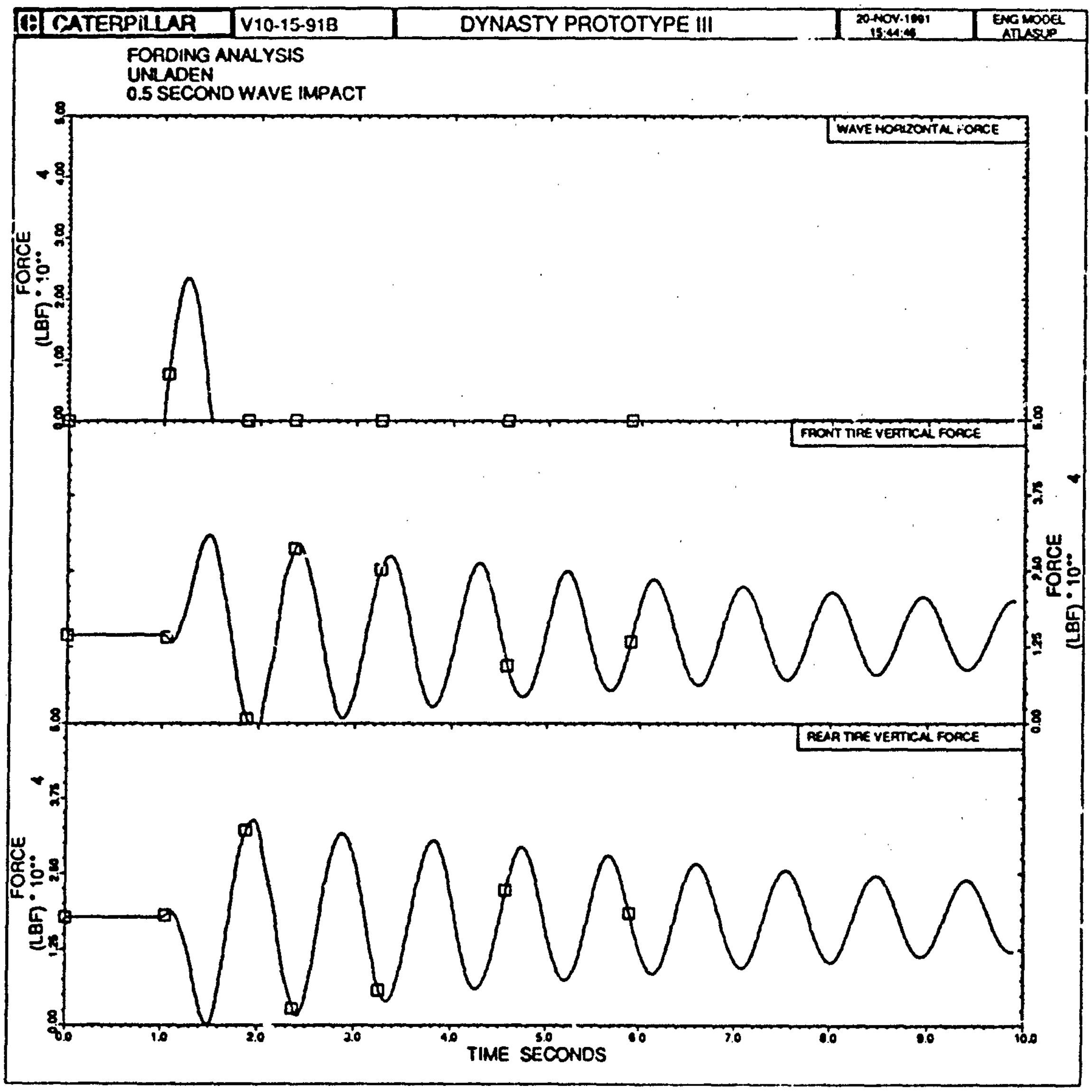


Figure 2.7-6 ATLAS Unloaded, 0.5 Second Wave Impact.

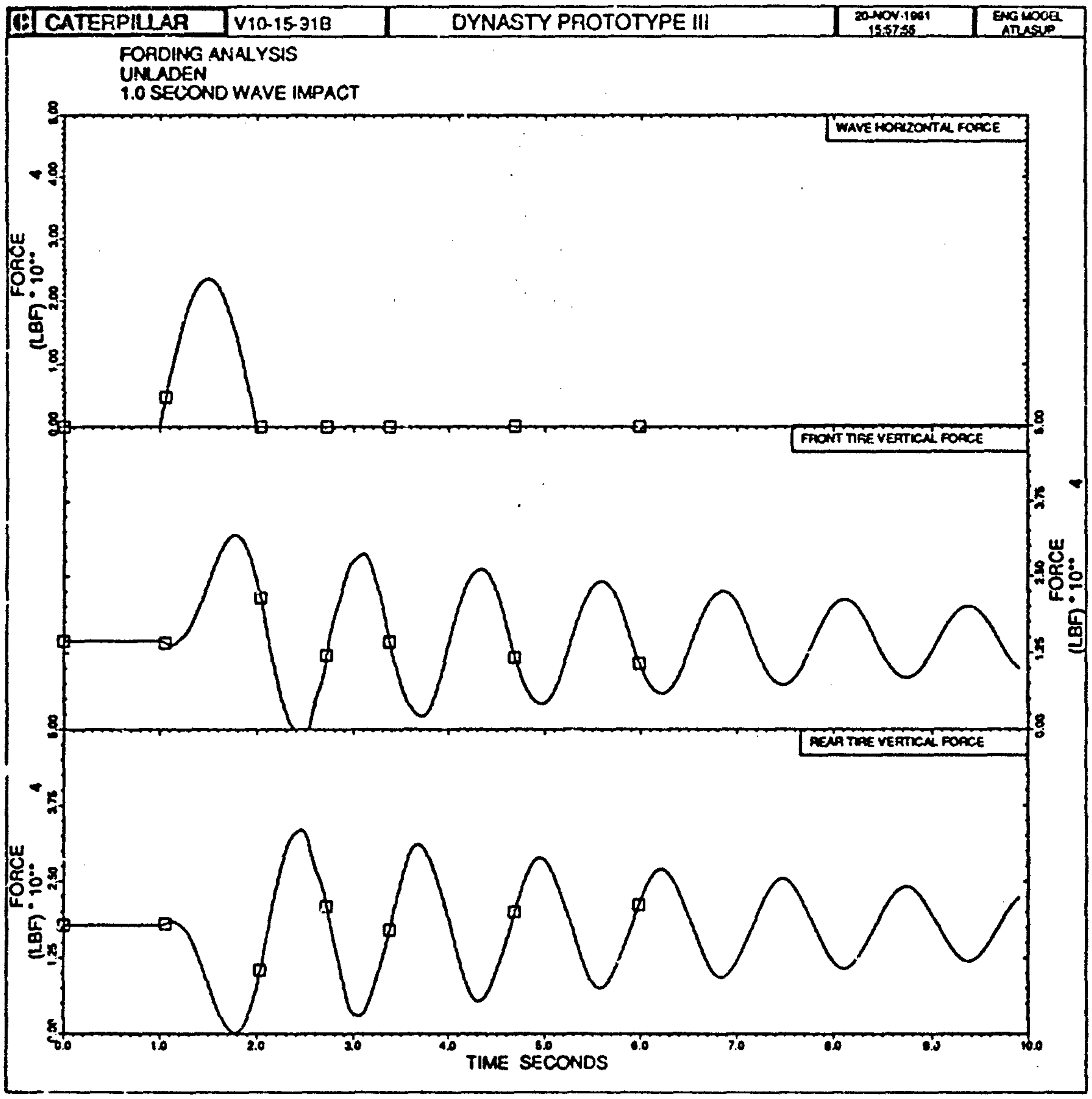


Figure 2.7-7 ATLAS Unloaded, 1.0 Second Wave Impact

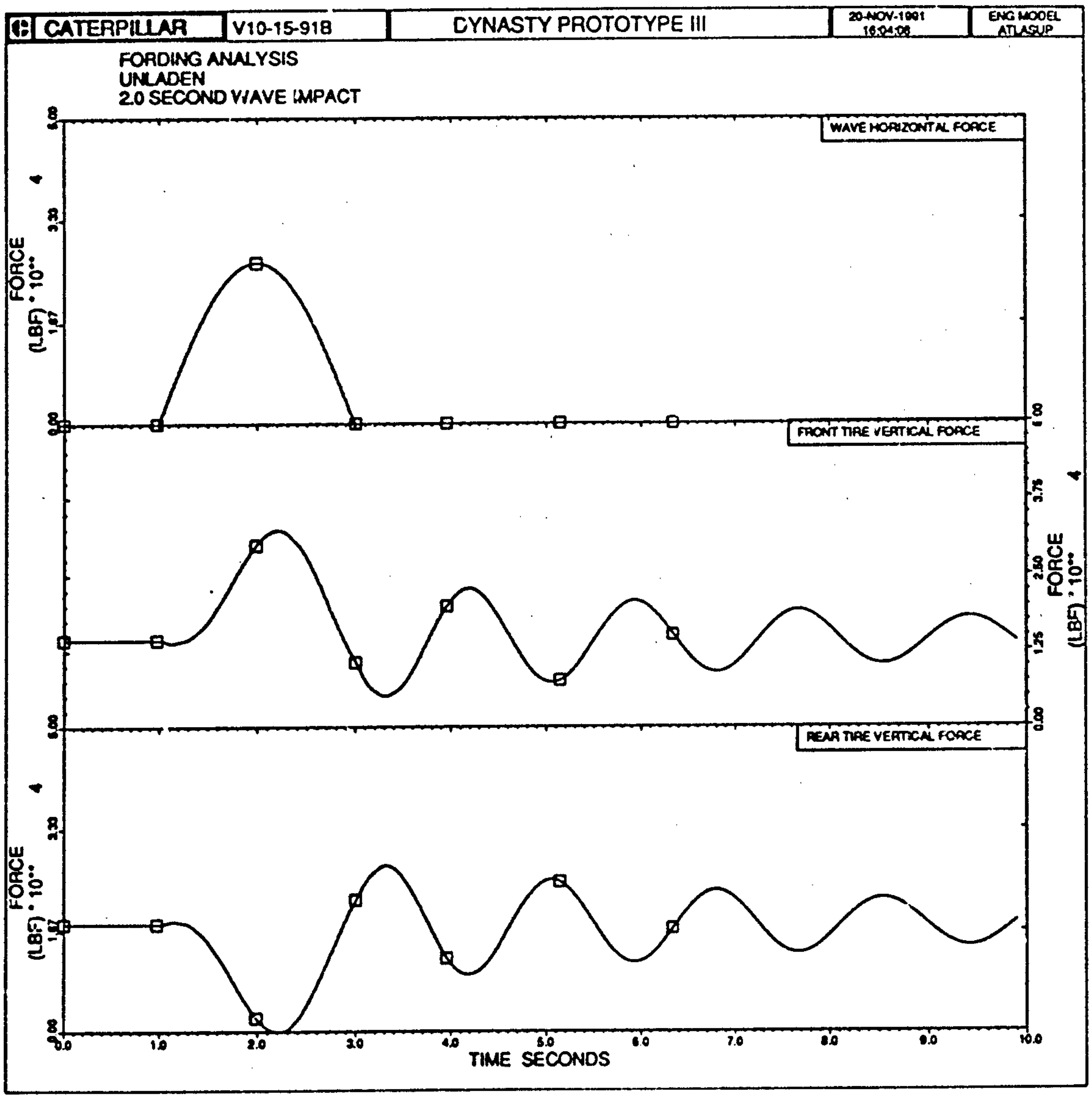


Figure 2.7-8 ATLAS Unloaded, 2.0 Second Wave Impact

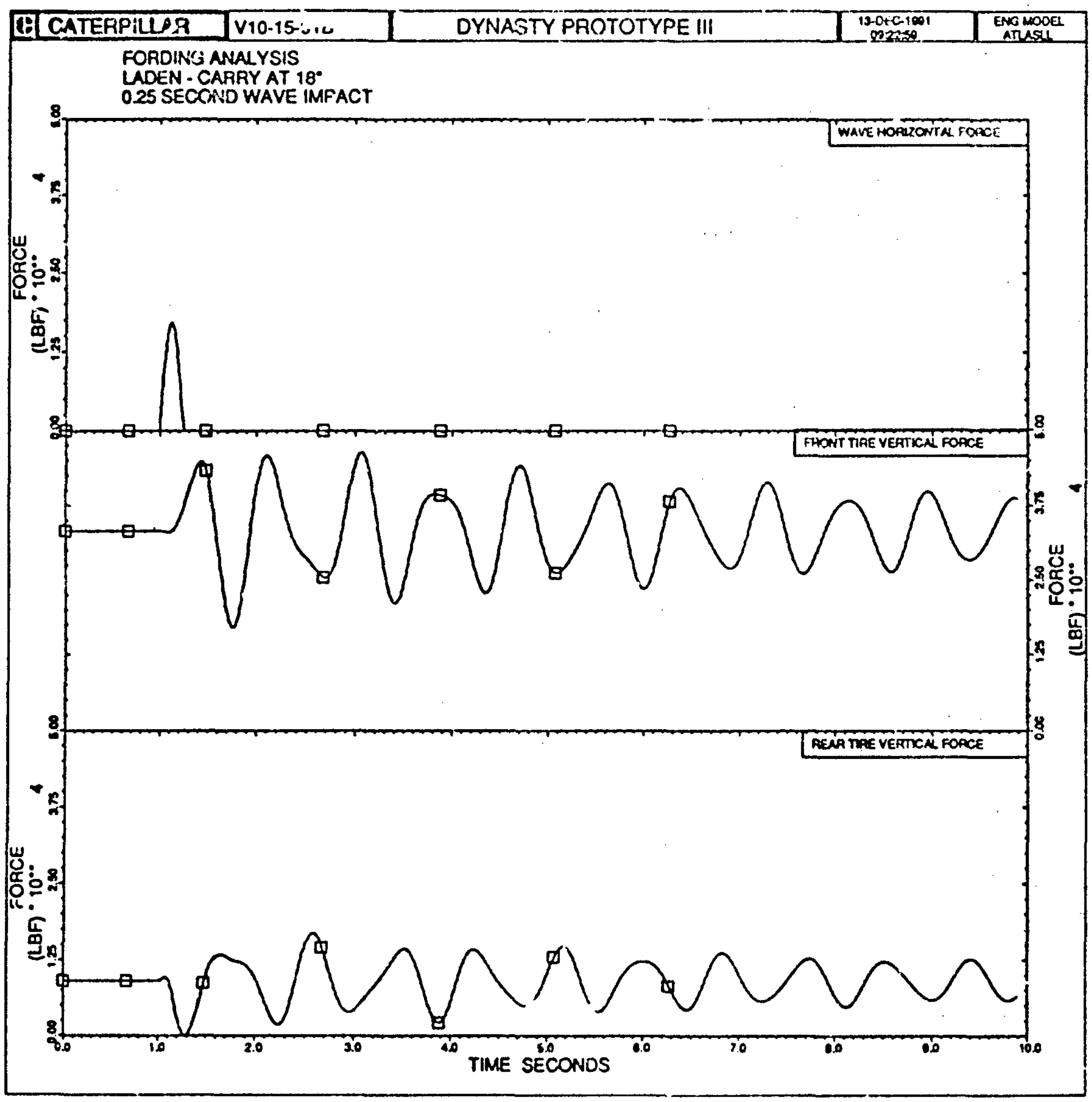


Figure 2.7-9 ATLAS Loaded, Load at 18" Height, 0.25 Second Wave Impact

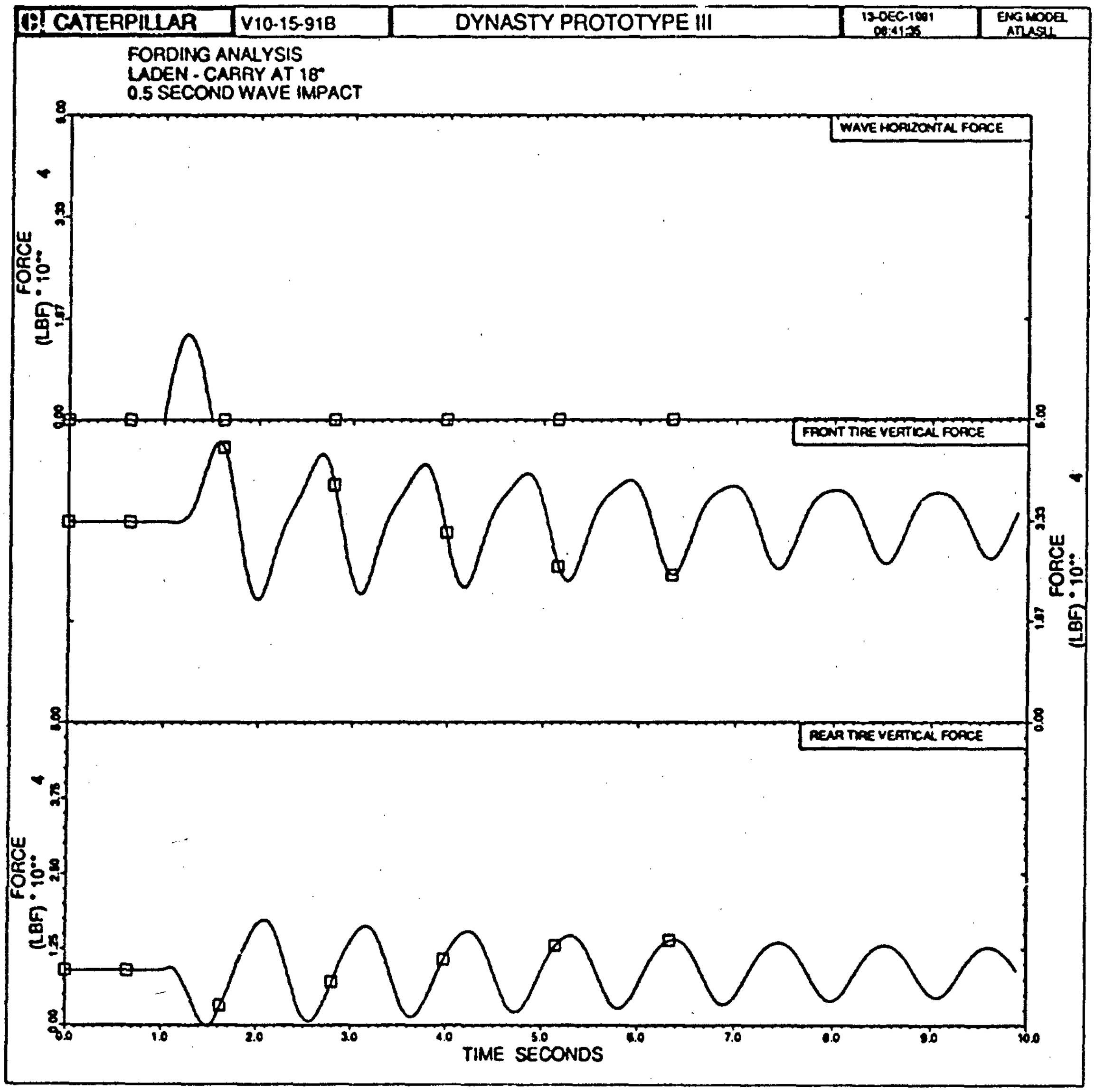


Figure 2.7-10 ATLAS Loaded, Load at 18" Height, 0.5 Second Wave Impact

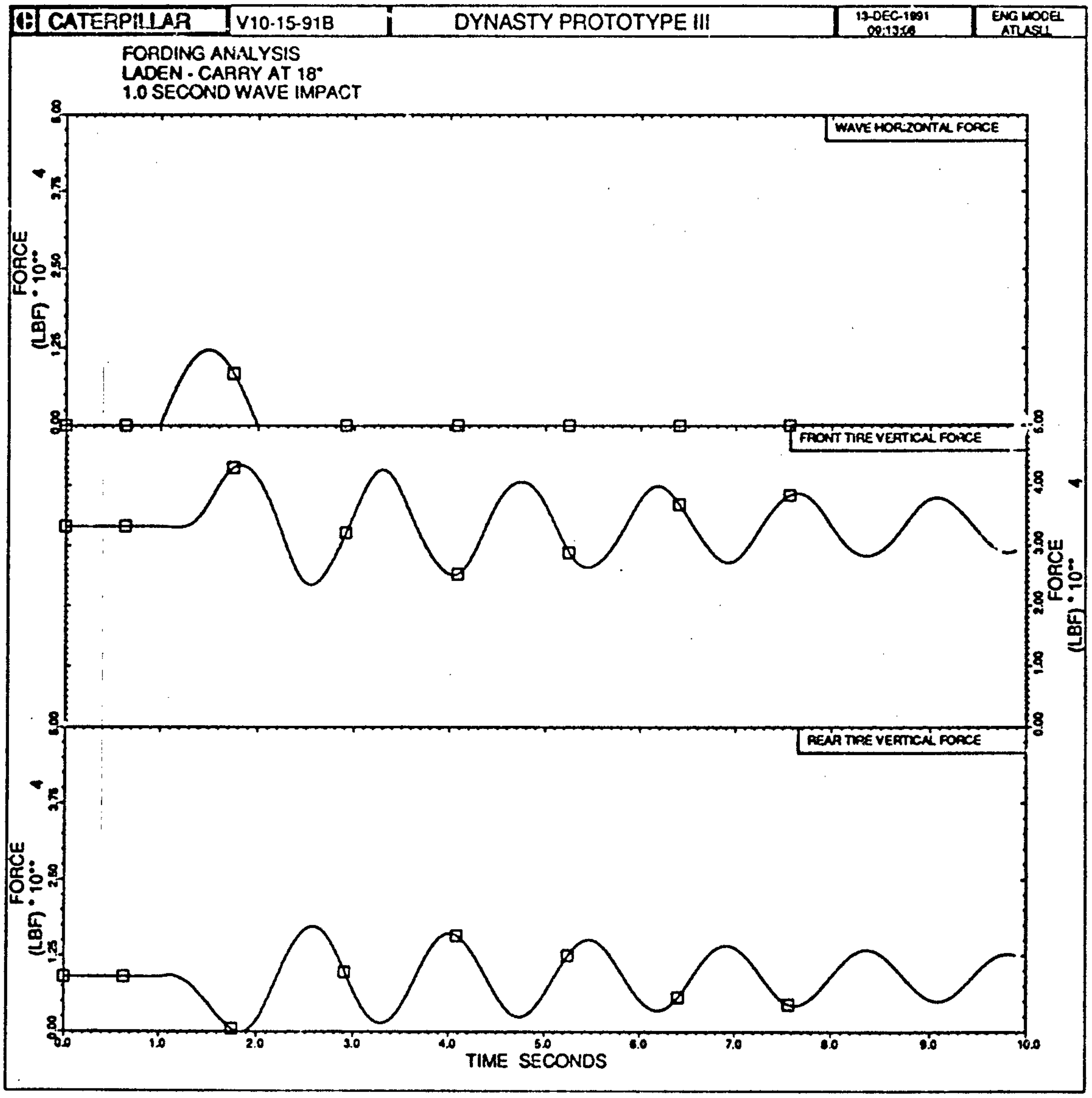


Figure 2.7-11 ATLAS Loaded, Load at 18" Height, 1.0 Second Wave Impact

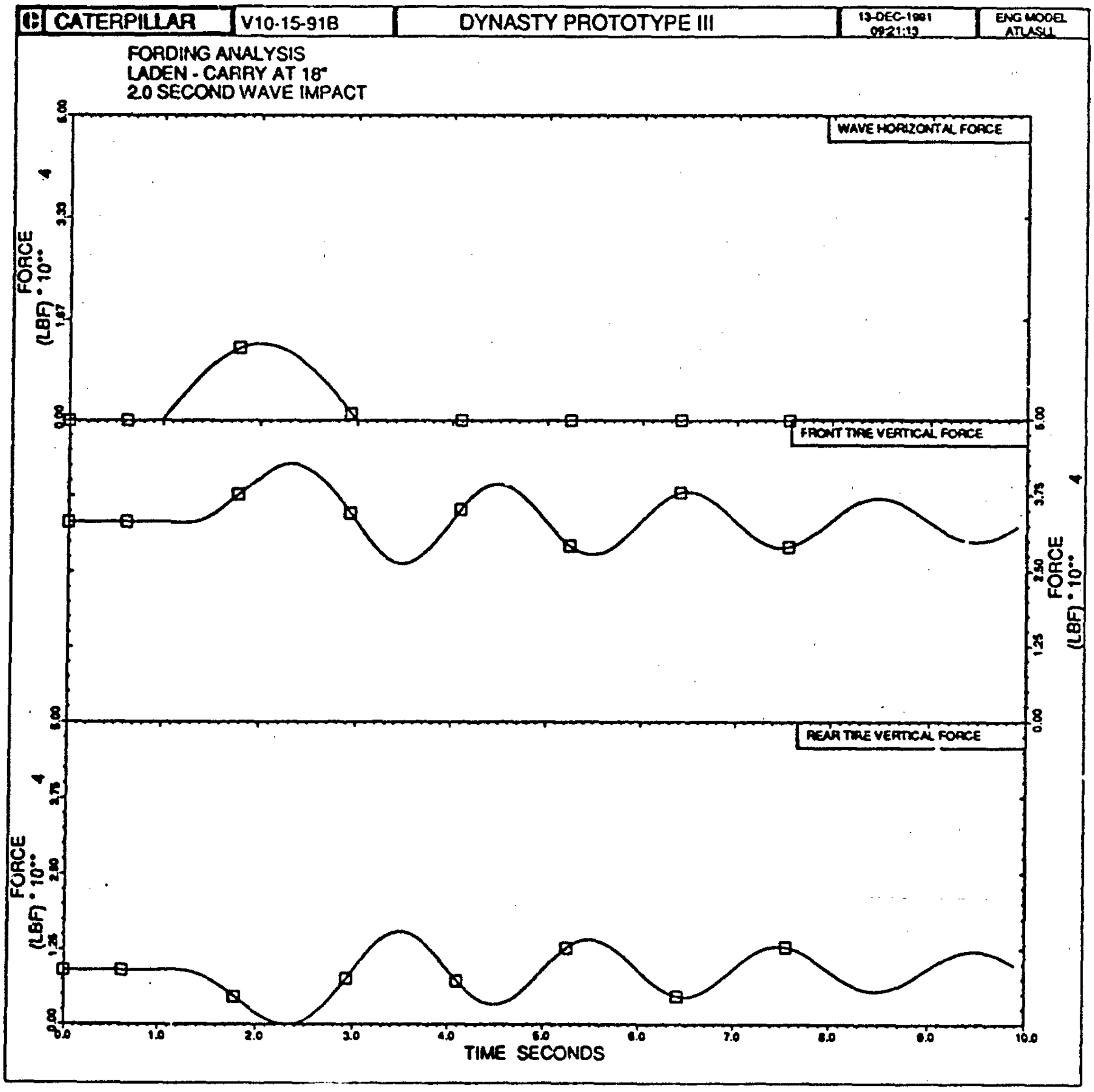


Figure 2.7-12 ATLAS Loaded, Load at 18" Height, 2.0 Second Wave Impact

Attachment 3
C130 Transportability Study

1.0 Transportability Background.

The ATLAS transportability requirements exceed the air transport requirements defined in MIL-T-53038 (ME) for the current 6K RTFL with the inclusion of C130 transport (Figure 1.0-1) requirement. Neither the C130 transport capability nor ATLAS performance shall be compromised per the technical guidance provided. Cab removal was not an option.

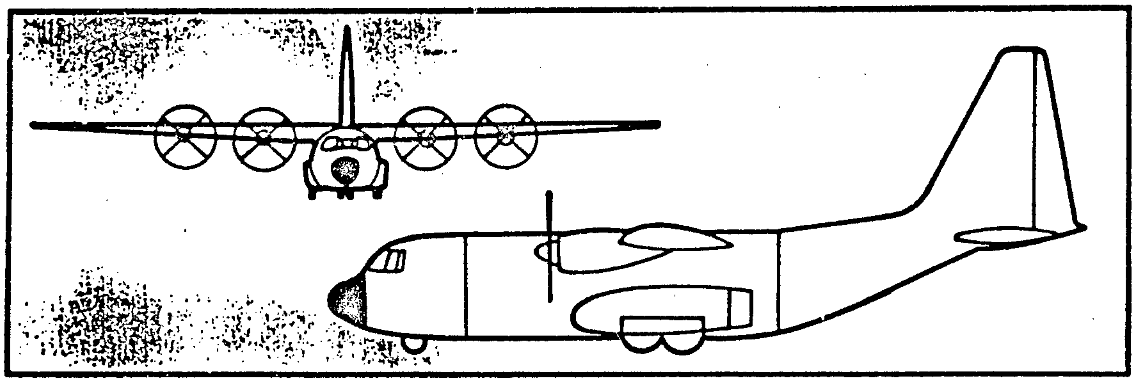


Figure 1.0-1 C130

The issue is multi-faceted centering primarily on weight distribution and envelope dimensions. The primary trade-off (to meet the 102" vehicle width defined) as a result of this study is vehicle performance versus additional preparation for C130 transport. Figure 1.0-2 provides the envelope (width and height) dimensions including the 5.5 inch rail that limits vehicle width including tire bulge to 102 inches.

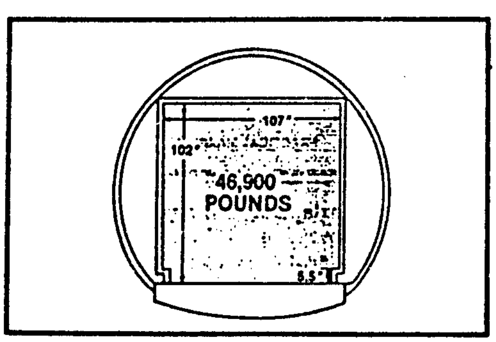


Figure 1.0-2 C130 Envelope Dimensions

1.1 Recommendations. A C130 transport configuration of ATLAS is achievable without compromising the operational configuration/performance with implementation of the following recommendations provided as a result of this study:

> *Provide the necessary resources to convert the ATLAS from operational configuration to a C130 air transport configuration.*
>
> *Provide the necessary resources to return the ATLAS to operational configuration at the theatre of operations.*
>
> *Provide consideration for an ATLAS C130 Transport Kit with maturation of the ATLAS Program.*

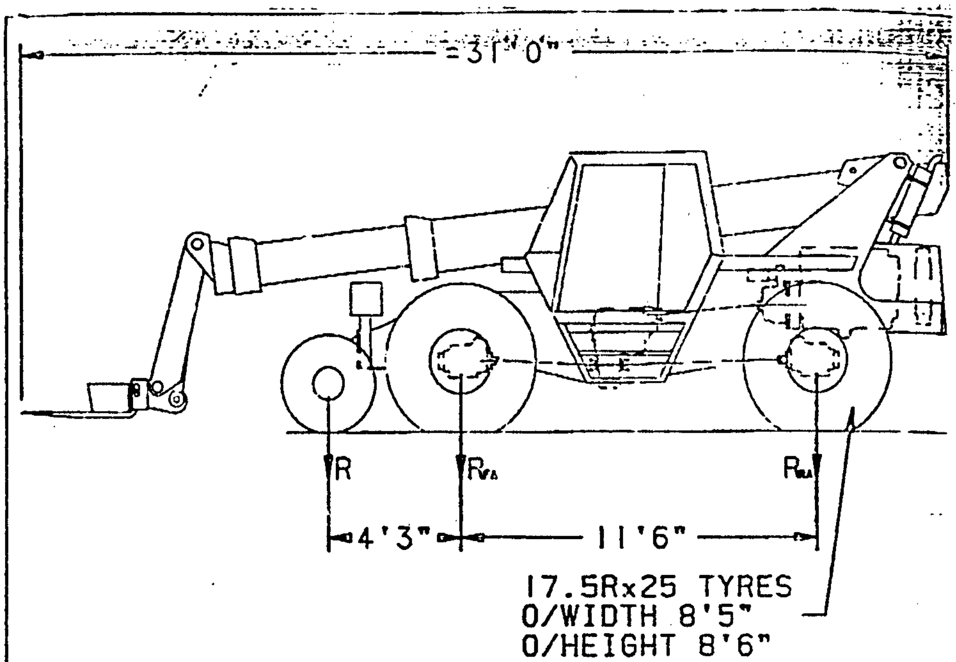
The need for an ATLAS C130 Transport Kit will be alluded to but the need for such a kit has not been established under the auspices of this effort.

1.2 Rationale. Given that C130 transportability parameters cannot be violated and vehicle performance is central to the safe and reliable completion of the ATLAS mission, the minimum allocation of resources (labor and materials) to prepare the ATLAS for C130 transport and restore the vehicle to operational configuration is the most cost effective and lowest risk approach.

1.3 Technical Approach. The technical approach centers on four techniques to convert the ATLAS from operational configuration to C130 air transport configuration;

a) Relocation of counterweight,
b) Extension of boom,
c) Addition of temporary 3rd axle, and
d) Reversal of the rim/wheels. if the 20.5R25 tires are used.

These activities will result in the required to provide the required weight distribution and envelope dimensions. Figures 1.3-1 and 1.3-2 provide two examples of potential transport configurations.



SCALE 1/4"=1'

BOOM OUT 4.88ft, ADD BALLAST TO FORKS TO RELIEVE REAR AXLE LOAD

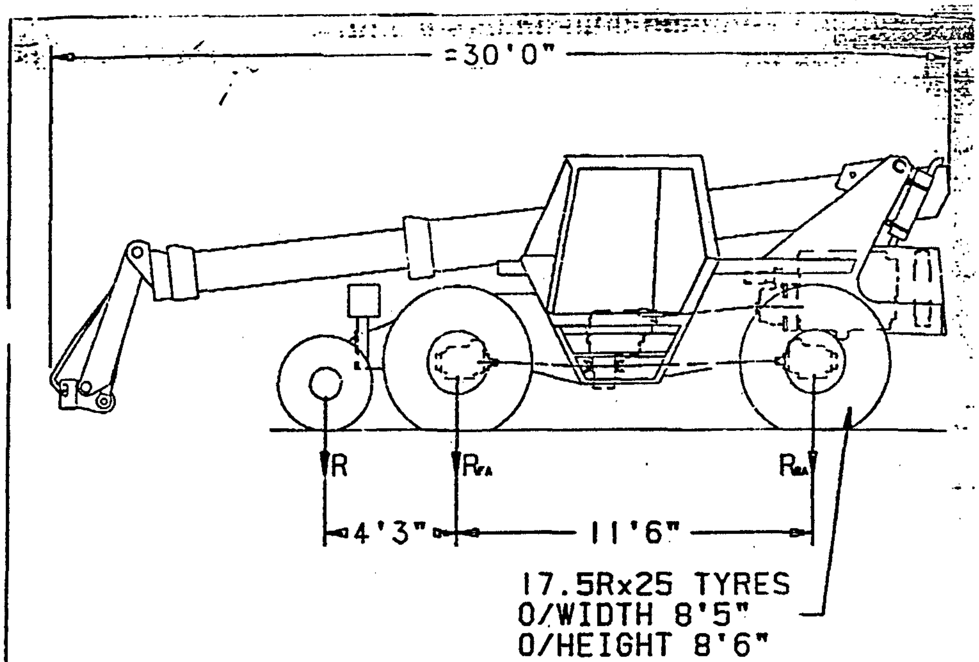
			FA	RA
FRONT AXLE	2600x	0/11.5	2600	0
REAR AXLE	2600x	11.5/11.5	0	2600
CARRIER	14100x	7.7/11.5	4660	9440
O/RIGGERS	2200x	-3.1/11.5	2793	-593
No 1 SECTION	1800x	6.75/11.5	744	1056
TELE'D BOOM	4800x	0.75/11.5	4487	313
HEAD	1950x	-9.5/11.5	3560	-1610
BALLAST	2200x	-11.25/11.5	4353	-2153
	32250		23197	9053

THRUST ON RELIEVING AXLE = 8200 lb
FRONT AXLE RELIEVED 8200x15.75/11.5 = 11230 lb
REAR AXLE ADDED 8200x 4.25/11.5 = 3030 lb
WEIGHT OF RELIEVING AXLE = 1900 lb

R_{FA} = FRONT AXLE LOAD = 23197-11230 = 11967 l
R_{RA} = REAR AXLE LOAD = 9053+ 3030 = 12083 l
R= RELIEVING AXLE LOAD = 8200+ 1900 = 10100 l

NOTE! ABOVE CALCULATIONS ALLOW FOR +7.5% GROWTH

Figure 1.3-1 establishes a 31 foot vehicle length with the ballast/counterweight secured to the forks of the extended boom.



SCALE 1/4"=1'

BOOM OUT 6.9ft AND REMOVE REAR BALLAST TO RELIEVE REAR AXLE LOAD.

			FA	RA
FRONT AXLE	2600x	0/11.5	2600	0
REAR AXLE	2600x	11.5/11.5	0	2600
CARRIER	14100x	7.7/11.5	4660	9440
O/RIGGERS	2200x	-3.1/11.5	2793	-593
No 1 SECTION	1800x	6.75/11.5	744	1056
TELE'D BOOM	4800x	-1.65/11.5	5488	-688
HEAD	1950x	-11.65/11.5	3925	-1975
	30050		20210	9840

THRUST ON RELIEVING AXLE = 6000 lb
FRONT AXLE RELIEVED 6000x15.75/11.5 = 8217 lb
REAR AXLE ADDED 6000x 4.25/11.5 = 2217 lb
WEIGHT OF RELIEVING AXLE = 1700 lb

R_{FA} = FRONT AXLE LOAD = 20210-8217 = 11993 lb
R_{RA} = REAR AXLE LOAD = 9840+2217 = 12057 lb
R= RELIEVING AXLE LOAD = 6000+1700 = 7700 lb

NOTE! ABOVE CALCULATIONS ALLOW FOR +7.5% GROWTH.

Figure 1.3-2 establishes a 30 foot vehicle length with the extended boom and the ballast/counterweight shipped separately.

Vehicle height of 101 inches for C130 transport is readily achievable with tire deflation.

1.3.1 Relocation of the Counterweight. Relocation of the counterweight is required to provide the necessary weight distribution. The counterweight of approximately 2200 lbs will be removed from the rear of the vehicle and relocated on the forks of the boom (to provide a more desirable weight distribution during transport) or transported separately (to reduce transport weight).

Outriggers would also be removed and relocated. For purposes of this study, outriggers are removed and shipped independently of ATLAS. Maturation of the ATLAS design will establish the need for outriggers and provide for alternatives to accommodate outriggers for C130 transport.

1.3.2 Extension of the Boom. Extension of the boom is necessary to shift the center of gravity of the vehicle forward by shifting weight from the rear axle to the front axle. With the counterweights stowed on the forks, extension of the boom may be minimized.

Total vehicle length including extension of the boom is limited to 480" (40 feet) on the C130.

1.3.3 Addition of the Temporary 3rd Axle. Application of a temporary 3rd axle is necessary to meet the axle weight limitations of (13,000/13,500 lbs) for the C130. Implementation of a 3rd axle is the classical alternative to removing weight from the vehicle. The projected gross vehicle weight of 32,500 lbs for ATLAS, though well within the 47,000 lbs maximum, would necessitate the removal of 6,000 lbs to be within the 26,500 permitted for a 2 axle vehicle.

The temporary 3rd axle would be located at the front of the vehicle and provide the required minimum spacing of 48 inches between axles. The wheels would be located in the treadways of the C130. The axle may require suspension to assure that sufficient load is carried by the axle during loading, transport, and unloading the ATLAS vehicle. The axle weight carried by the 3rd axle would be limited to 13,000 lbs (if the wheels are located on treadways) and 5000 lbs (if wheels are located between the treadways). Figures 1.3-1 and 1.3-2 project axle loads of 10,100 and 7,700 lbs respectively.

Provisions may be made to stow the 3rd axle on the ATLAS vehicle when not in use or provide the axles with the ATLAS C130 Transport Kit as required.

1.3.4 Reversal of the Rim/Wheels. Reversal of the wheels is required to provide the necessary vehicle width of 102 inches for C130 transport if 20.5R25 tires are used. The rim would be designed with an offset such that when the offset was outboard the vehicle would be configured for working. Alternatively when the offset was inboard, the vehicle would be configured for C130 transport.

1.3.5 ATLAS C130 Transport Kit. An ATLAS C130 Transport Kit may be determined to be a more cost effective approach than providing the 3rd axle and supplemental tools and materials to reconfigure ATLAS for C130 transport. The need for such a kit was not defined under this contract. The definition of this kit should not be precluded from further consideration with the maturation of the ATLAS design.

Integrating the design features to required for C130 transportability may add 5% to 10% to the cost of each vehicle. Implementation of a reusable kit could avoid a substantial portion of that cost. Unfortunately, a transport kit introduces the logistics problem of mating a kit with the vehicle when required.

2.0 Transportability Requirements.

Transportability criteria are established by MIL-STD-1366 and MIL-HDBK-157. The following paragraphs are taken from MIL-T-53038(ME); recommendations/comments are provided in sub-paragraphs. The RTFL shall be transportable worldwide without damage, by highway, air, marine, and rail transport modes.

2.1 Highway Transportability. The RTFL shall be capable of being towed with a dead engine without damage. The drivetrain shall be provided with a means to disengage the wheels from the transmission for towing. Disengagement and reengagement shall each be performed in not more than one hour by one person using only manual devices and common tools. The forklift, in its reduced configuration, shall be capable of highway movements worldwide when transported on US Army M871 semitrailer, and highway transportable in NATO countries. The RTFL shall not exceed the permit limits as defined in Table I of MIL-HDBK-157 for transport in CONUS, excluding Guam and Puerto Rico.

(No substantiative departure from the 6K RTFL to meet the ATLAS requirements is anticipated.)

2.2 Air Transportability. The forklift shall be transportable in USAF C130, C140, and C-5A aircraft. Transportability requirements shall be in accordance with MIL-A-8421, Air Force Design Handbook DH1-11, and as specified herein. The fully assembled forklift truck shall be capable of being driven on and off the aircraft. The air transport configuration shall be with a minimum of 1/2 to a maximum of 3/4 tank of fuel.

<u>2.2.1 C130 Air Lift Configuration Recommendation.</u> The fully assembled forklift truck should provide for an air lift configuration with sufficient time and resources to convert the ATLAS from the operational configuration to an air lift configuration.

2.2.2. Tools and Time Allocation Recommendation. Conversion of ATLAS from the operational configuration to the C130 air lift configuration will require additional time and effort. The conversion may be accomplished with on-board tool incorporating features of the ATLAS vehicle or with consideration for an ATLAS C130 Transport Kit. Sufficient personnel must be provided for the conversion to be completed in a safe and reliable manner.

2.2.3 Technical Order C130A-9. Technical Order C130A-9 (Figure 2.2.3-1) provides for the on/off loading of heavy duty forklifts. Notably, the TO provides for "remove cab top, doors, counterweights, and rollerized tines and place on a separate pallet for shipment" and a reduction in fuel load if required. The extent to which this TO will be applicable to ATLAS has not been determined, i.e. ATLAS shall exceed the 26,500 lb limitation. The TO implies that resources and materials are allocated to prepare RTFLs for C130 transport.

Table 6A-34. Heavy Duty Forklifts

NOMENCLATURE	CONFIGURATION	DIMENSIONS			WEIGHT
		LENGTH	WIDTH	HEIGHT	POUNDS
Heavy Duty Forklifts					26,500

ON/OFF LOADING METHODS

NOTE

Due to the numerous model designations and manufacturers, the models are not specified. However, the procedures below apply to adverse and rough terrain forklifts, respectively.

1. Remove cab top, doors, counterweights, and rollerized tines and place on separate pallet for air shipment.

NOTE

Removal of counterweights and rollerized tines are not required when the added weight does not exceed 13,500-pound axle weight. One axle may weigh 13,500 and the other axle will not exceed 13,000 pounds. The gross weight will not exceed 26,500 pounds.

2. If forklift is to be shipped in the operational mode, do not exceed the limitations in the NOTE above Fuel load may be reduced if required to remain within limits.

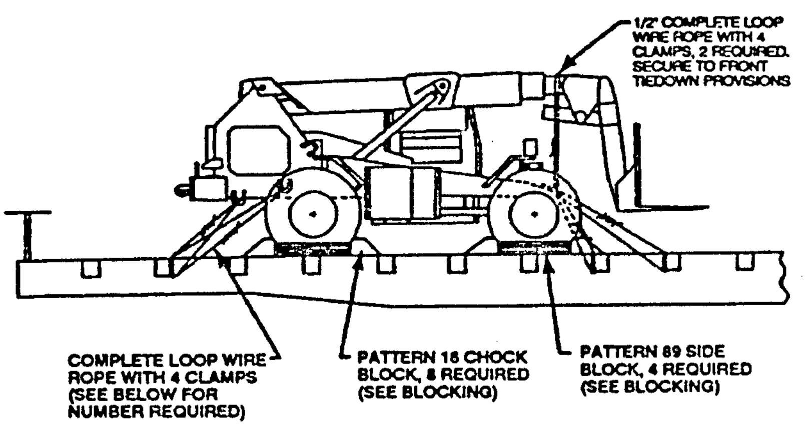
3. Sleeper shoring is required.

Figure 2.2.3-1 Technical Order C130A-9

2.3 Rail Transportability. The forklift shall have unrestricted movement by railroad when loaded on a 50-foot flat car (see MIL-HDBK-157)/ The forklift shall withstand railroad bumping without permanent deformation or damage to any of its components when secured to the flatcar in accordance with the Association of American Railroad (AAR) Rules Governing the Loading of Department of Defense Material on Open Top Cars. The railroad bumping test shall be in accordance with the AAR General Rules Governing the Loading of Commodities on Open Top Cars (Section 1, Part 3).

No substantiative departure from the 6K RTFL to meet the ATLAS requirements are anticipated. MTMCTEA PAM 55-19 provides guidance for the securing of Variable Reach Forklift Truck, 6000 lb (Figure 2.3-1). Note that the table also provides for GVWs between 25,000 and 38,000 lbs that bracketed the 32,500 lbs projected for ATLAS.

Variable Reach Forklift Truck, 6,000 lb



VEHICLE WEIGHT RANGES (LB)	6 X 19 IWRC IPS ROPE	
	CABLE SIZE (DIA, IN.)	NUMBER OF CABLES (COMPLETE LOOP)
0-14,000	3/8	4
14,000-25,000	1/2	4
25,000-38,000	5/8	4
38,000-50,000	1/2	8
50,000-76,000	5/8	8

NOTE: FROM GENERAL RULES, SECTION NO. 1.

Figure 2.3-1 MTMCTEA PAM 55-19 Provide Guidance For Securing Variable Reach Forklift Truck, 6,000 lb

2.4 Marine Transportability. The forklift shall be transportable by breakbulk cargo ships, roll-on/roll-off (RORO) ships, C-8 and larger, lighter aboard ship (LASH), barge carrying ships (SEABEE), LARC60 and larger amphibious vessels, and army barges and lighters in accordance with MIL-HDBK-157.

No substantiative departure from the 6K RTFL to meet the ATLAS requirements are anticipated.

2.4.1 ISO Container Transport. ATLAS may be transported via an ISO platform (flat rack) container.

Initially, marine transport by ISO Series 1 container was desirable. This desired feature was deleted from further consideration because the requirements of this transport mode were far more stringent than C130 transport requirements. Specifically, vehicle width and height would be limited to 91 inches, i.e. an 11 and 10 inch reduction in width and height, respectively, from what is allowed for C130 transport.

Alternate containers were investigated. A limited number of "tall" Series 1 containers providing for 101" height are available. The availability of "tall" Series 1 containers has not been established. Open top containers provide additional latitude in height but no additional latitude in width. Only the aforementioned, platform (flat rack) ISO container has been identified to meet a requirement for ISO containerization and transport. Subsequent establishment of a requirement and maturation of the ATLAS program and design may necessitate that this issue be addressed.

3.0 Vehicle Performance Considerations.

Off-road performance of the RTFL in an undulating terrain is strongly influenced by a number of factors including gage of the vehicle, i.e. the wider the gage the more stable the lifting and transport platform. RTLFs provide hydraulic cylinders to level the frame for lifting the load.

Notably the tire size and footprint strongly influences mobility of the vehicle particularly in soft underfootings typical for LOTS operations.

3.1 Vehicle Gage. The vehiclc gage is defined at the center-to-center dimension between the tires. The vehicle gage is established by the flange-to-flange dimension of the axle, the offset of the rim, and the tire width. The vehicle width for C130 transport is limited to 102" by siderails to a height of 5 inches from the groundline.

Given that all other factors are held constant, the wider the vehicle gage the more stable the platform on side slopes.

3.1.1 Tire Size. Two tire sizes (17.5Rx25) and (20.5Rx25) are considered for the ATLAS. The 20.5Rx25 is necessary to meet the mobility requirement for speed, specifically the dash speed of 50 mph with an achievable axle ratio of 10:1.

The 17.5Rx25 tire is under consideration only to meet the C130 vehicle width limitation of 102" with widest commercially available axle arrangement. Implementation of the 17.5Rx25 tire compromises dash speed and the vehicle's capability to negotiate soft soil conditions.

The capability of a vehicle to negotiate soft soil condition is a function of its footprint, i.e. wider tires provide increased cross-sectional area in contact with the ground, hence more flotation and increased mobility. The 20.5Rx25 tire provides 1.17 times the width of the 17.5Rx25 tire. The ability to negotiate soft soil conditions may be described by a number of empirical indices including Mobility Index (NATO Reference Mobility

Model), Flotation Index (MIL-STD-53038) (ME), and Min-Max Pressure favored by British MOD. The Flotation Index recognizes that RTFLs, except under unique loading conditions, have an unequal weight distribution between axles.

3.1.2 Rim Offset. Rim offset provides the option for relocating the centerline of the tire and rim with respect to the axle hub. The wheel may be moved outboard or inboard. A single rim design may provide offsets on the order of 2 through 8 inches. A reversible rim would require that the geometry of the clearance holes provide for reversal of the rims.

3.1.2.1 Engineering Considerations. Changing the rim offset changes the loading on the roller bearings necessitating engineering review and possible redesign. Briefly, the axle hub includes the axle flange (to which the rim bolts) and distributes the loading through the axle bearings to the spindle. The bearings are sized to accommodate the expected loading.

3.1.2.2 Steering Restriction. Reversing the rims to facilitate C130 transport, i.e. offsetting the rim inboard would reduce the maximum steering angle by a limited, but measurable number of degrees. Maturation of the ATLAS design would determine the extent to which maneuverability is degraded in the C130 transport configuration.

The three modes of steering provided by RTFLs, Ackerman, crab, and countersteer provide sufficient maneuverability to the C130 configured ATLAS that it can accomplish the C130 drive on/ drive off maneuvers. Maturation of the ATLAS design will provide for the technology required to limit the steering angle in the C130 transport configuration. The electronic over hydraulic controls may be utilized to provide "soft" steering angle limitation. Alternately, the axle housing may be modified to provide a "hard" steering angle limitation. A bolt/pin-on stop could be provided with the ATLAS C130 Transport Kit or a stowage location provided on the ATLAS vehicle.

3.1.3 Axle Width. Steerable axles as required for the 3 steering mode operation of the ATLAS RTFL are available with a limited variety of flange-to-flange dimensions. Substantiative alterations to this dimension are not trivial nor recommended at this time. Notably RTFLs provide for a steering angle of 37 degrees. Axles configurations with flange-to-flange dimensions of 73 and 85 inches have been considered.

3.1.3.1 73" Axle. The 73" axle is under consideration only to meet the C130 vehicle width limitation of 102" with the 20.5Rx25 tire. A rim offset of 4.25 would meet 102" required for air-transport but would limit the operational configuration to 102".

3.1.3.2 85" Axle. The 85" axle would provide a vehicle width of 108 inches with the 20.5Rx25 tire providing a more stable lift and working platform. An offset of 3 inches would be required to meet C130 transport requirement.

The 85 inch axle provides a 16% increase in the flange-to-flange dimension over the 73 inch axle.

3.3 Weight/Weight Distribution. Proper weight/weight distribution is central to the performance and transportation of 32,500 lb ATLAS. In the working mode (unloaded) the rear axle carries more weight (approx. 17,970 lbs) than the front axle (approx. 14,288 lbs). Note that each axle exceeds the maximum axle weight permitted by TO 1C130A-9 of 13,000/13,500 lbs.

3.3.1 Engineering Consideration. Substantial increases in gross vehicle weight are not a viable alternative to meeting the transportability requirements hence a temporary 3rd axle was considered in lieu of provisions to remove more weight. Provisions to remove more weight (6000+) for transport may have necessitated unacceptable weight growth compromising both dash speed and soft soil mobility.

4.0 C130 Transport Configuration Considerations, Preparation For.

Preparation for C130 transport is generally desired to be 1 hour. Alternatively preparation for C130 transport of ATLAS will require 3-4 hours without compromising the operational performance of the vehicle. Preparation for C130 transport will consist of the following:

Activity	*Lapse Time Estimated (mirutes)*
1) *Removal of Counterweight,*	*15*
2) *Addition of the 3rd axle, and*	*45*
3) *Reversal of the Rims/Wheels.*	*120*
4) *Extension of boom,*	*1*
5) *Miscellaneous Activity*	*59*

4.1 Counterweight. Removal of the counterweight (2200 lbs) may be accomplished using the boom per Figure 4.1-1. The number 2 section of boom will be partially extended. A cable(s) will be routed from number 2 section, over a pulley, and secured to the counterweight. The number 2 section of boom will be extended relieving the weight off the pins that secure the counterweight to the frame. The counterweight will be unpinned and the boom retracted to lower the counterweight safely to the ground. The vehicle can then engage its counterweight with the forks secured.

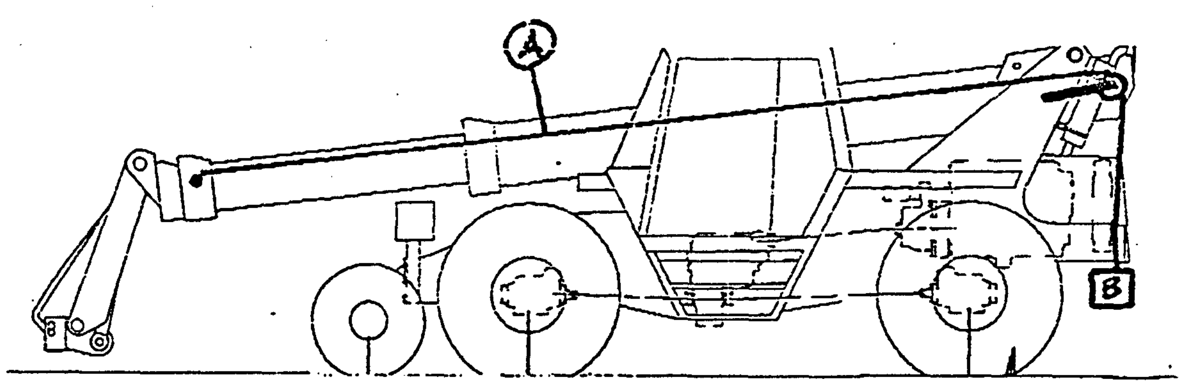


Figure 4.1-1 Removal Of The Counterweight May Be Accomplished By Using The Boom

4.2 Addition of the 3rd Axle. Maturation of the ATLAS design may provide for addition of the 3rd axle. As a minimum the temporary 3rd axle will include a structure (cross axle and mounting features) and hydraulic cylinders.

4.3 Reversal of Rims/Wheels. Reversal of the wheels can be accomplished in a variety of ways. Basically, this operation requires that each wheel be lifted clear of the ground, the lug nuts/bolts loosened and removed, the wheel be safely rotated 180 degrees, the wheel reinstalled on the hub and secured.

The wheels on the front axle may be readily cleared from the ground by dropping the boom to the ground and hydraulically lifting the front of the vehicle until the wheels clear the ground. The rear axle may then be chocked to positively preclude accidental shifting of the vehicle.

The wheels of the rear axle can be raised using a similar technique except that a sufficient load must be engaged with an over-extended boom that will lift the rear axle off the ground. The axle may then be chocked wheels reversed. Another option is to use a jack to raise the rear axle off the ground. The jack may be obtained from maintenance or be provided as part of an ATLAS C130 Transport Kit.

<u>4.3.1 Safety Concern.</u> Handling/reversing the wheels introduces an Operator/ maintainer safety concern that may be mitigated by implementing standard military maintenance practices to remove and replace a tire on RTFLs. This approach may require allocation of maintenance resources not typically associated with C130 transport operations though Technical Order 1C130A-9 alludes to the allocation of maintenance/operator resources to remove cabtop, doors, counterweights, rollerized tines, etc.

4.4 Extension of the Boom. Extension of the boom is required to relieve the weight on the rear axle and transfer that weight to the temporary 3rd axle in particular. Extension of the boom may be decreased if the counterweights (and perhaps other miscellaneous elements) are secured and transported on the forks. The 3rd axle must accommodate between 7000 and 10000 lbs. Extension of the boom to the desired length (between 4.88 and 6.9 feet) will require less than a minute.

4.5 Miscellaneous Activity. This task provides for undefined miscellaneous activity necessary to prepare the vehicle for shipment including implementation of the sleeper shoring, securing the vehicle within the C130, removal of fuel, etc.

4.6 ATLAS C130 Transport Kit. Definition of an ATLAS C130 Transport Kit may be determined to be the most cost effective approach to providing the 3rd axle and supplemental tools and materials to reconfigure ATLAS for C130 transport. The trade-off is between configuring each ATLAS vehicle with materials necessary for air transport or providing and distributing those materials in a limited number of kits.

At a minimum the kit may include:

1) the temporary 3rd axle,
2) jack,
3) steering stops, and
4) hardware.

The kit may be provided in a reusable container suitable for C130 transport with the ATLAS vehicle. The container may be used to transport materials that would otherwise be palletized. Upon arrival at the theatre of operations, the container would be readily matched with the associated vehicle for reconfiguration. The container would then be reused to stow the elements of the transport kit until required for return shipment. Perhaps the kit could be returned with the C130 for installation on the next ATLAS to be transported to the theatre of operations.

The need for such a kit has not been defined nor provided for under the auspices of this effort. The definition of this kit should not be precluded from further consideration with the maturation of the ATLAS design.

Attachment 4
NBC Contamination Of Hydraulic System

1.0 Operation in Contaminated Environments.

The ATLAS vehicle will operate in a NBC contaminated environment to fulfill its mission. Once that operation is completed, all elements and subsystems of that vehicle must be decontaminated.

1.1 Definition of the Problem. The hydraulic system may be contaminated by particles breaching the system via the vent/breather of the hydraulic reservoir. The hydraulic reservoir is vented to and operates at atmospheric pressure. The vent of the hydraulic reservoir permits changes in the level of the hydraulic fluid to accommodate the hydraulic oil demands of the ATLAS vehicle. Without the vent the hydraulic tank would be subject to internal pressures greater than or less than atmospheric pressure depending on the fluid level.

As the hydraulic demand increases, i.e. the hydraulic fluid level decreases, the vent introduces outside (contaminated) air in the reservoir. The air is purged as the hydraulic level increases.

1.2 Recommendation. Define a requirement for a sealed hydraulic system for ATLAS to minimize the potential for contamination of the hydraulic system by NBC agents.

2.0 Technical Approach.

Three alternatives have been identified to address the problem:

a) Seal hydraulic system,

i) External

ii) Internal

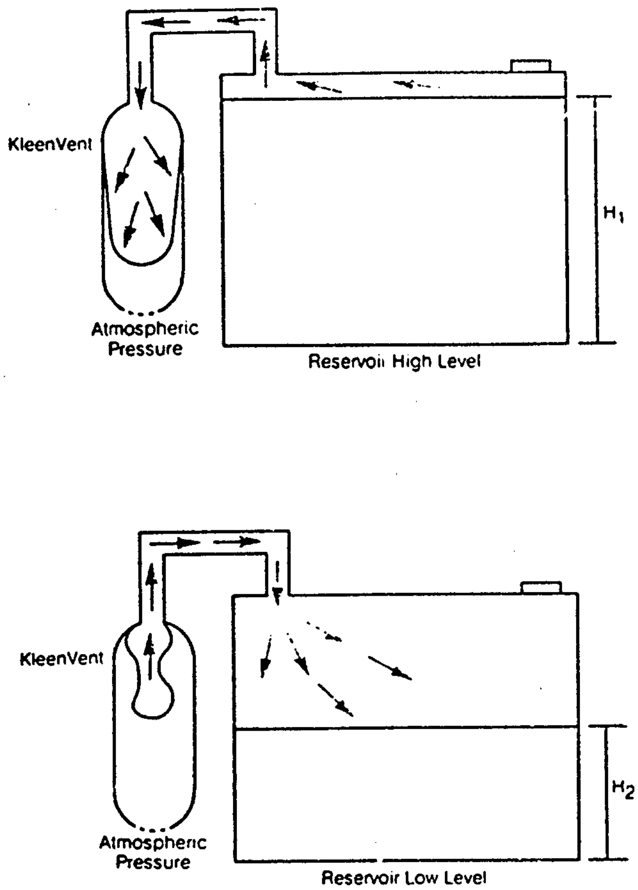
b) Add filter to the vent/breather, and

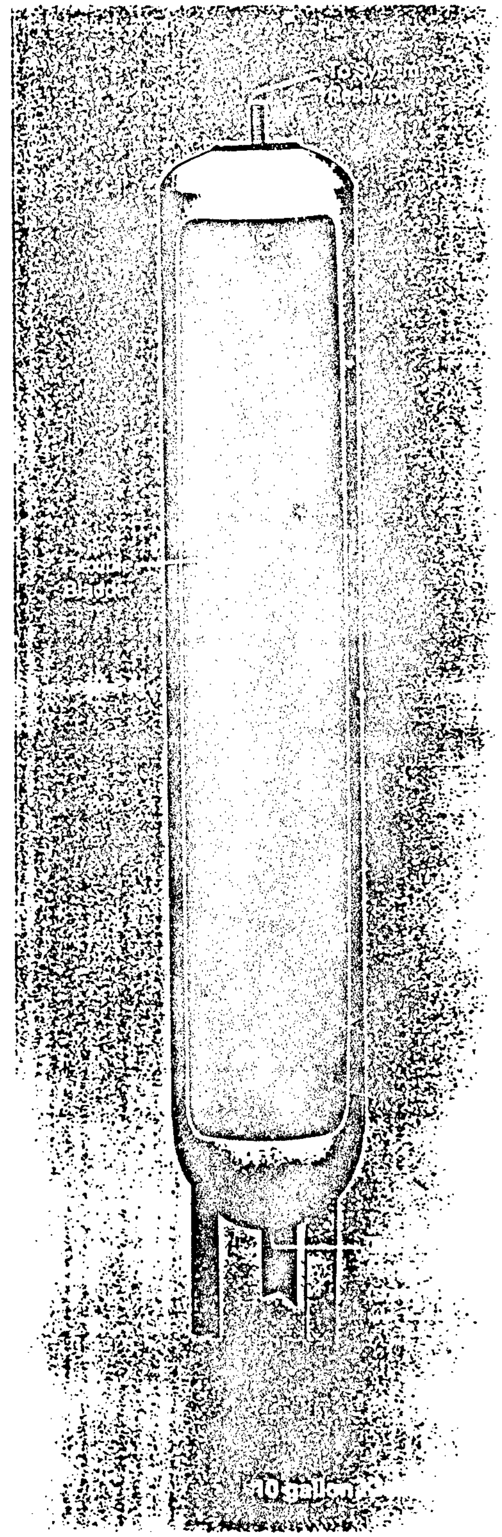
c) Do nothing.

The sealed hydraulic system provides a positive separation between the contaminated environment and the hydraulic fluid, whereas the addition of the filter would provide quasi-temporary separation. Finally, the do nothing approach would necessitate maintenance resources to fully decontaminate ATLAS.

2.1 Seal Hydraulic System-External. A sealed hydraulic system would require the addition of an external bladder in series with the hydraulic reservoir (Figure 2.1-1). Commercial off-the-shelf accumulator technology, such as the Greer Hydraulic KleenVent, exists to seal the hydraulic system from outside (contaminated) air.

Greer recommends a functional pressure/relief valve between the hydraulic tank and the external accumulator. The valve would ingest or purge outside air when the internal system pressure exceeds preset amounts.





To determine the proper size KleenVent, use the following formula, then refer to the working capacity on the chart on page 5. Select the nearest size.

Example: Reservoir length x width x $(H_1 - H_2)$ =

KleenVent volume required in cubic inches

- Greer Hydraulics recommends that every KleenVent installation be equipped with a functional pressure/ vacuum relief valve to protect the reservoir in the event of sudden fluid loss
- KleenVent should be installed when the reservoir level is at its high mark. This will allow the bladder to deflate as the reservoir level drops. The unit should be installed in a vertical position for optimum performance

Figure 2.1-1 Greer Hydraulic KleenVent External Bladder

<u>2.1.1 Theory of Operation.</u> The bladder acts as a "lung" expanding and contracting to accommodate the changes in gas volume of the hydraulic reservoir. Instead of outside contaminated air being ingested and purged, the clean air within the sealed hydraulic system is "reused". The external surface of the bladder and the enclosure would be contaminated but may be readily decontaminated via standard decontamination procedures with DS2.

<u>2.1.2 Engineering Consideration.</u> The bladder must be sized to accommodate the differential volume of hydraulic oil at operating temperature in the reservoir. In simplistic terms, the required size in cubic inches may be defined as follows:

$$\text{Reservoir Volume Required} = (\text{Length} \times \text{Width}) \times (H1 - H2)$$

where $H1$ = *Low Level of the reservoir*
$H2$ = *High Level of the reservoir*

The bladder is typically enclosed in a steel or fiberglass cylinder permitting remote location. A line is then routed to the bladder from the hydraulic reservoir.

<u>2.1.3 Engineering Concern.</u> The bladder and enclosure may require a substantial space claim. Implementation of the pressure valve will be required to minimize space claims for the accumulator

<u>2.1.4 Operational Concern.</u> The pressure valve may ingest contaminants if activated during an operation in a contaminated environment.

2.2 Sealed Hydraulic System-Internal. The sealed hydraulic system may include an internal bladder within the hydraulic reservoir (Figure 2.2-2). The same theory of operation and engineering consideration would be applicable to the internal bladder as to the external bladder though several differences exist.

Breather bags provide in-tank protection against air contamination

A breather bag is a synthetic rubber bag which provides a permanent flexible non-porous barrier between the atmosphere and the system fluid without affecting the operational functions of the system components.

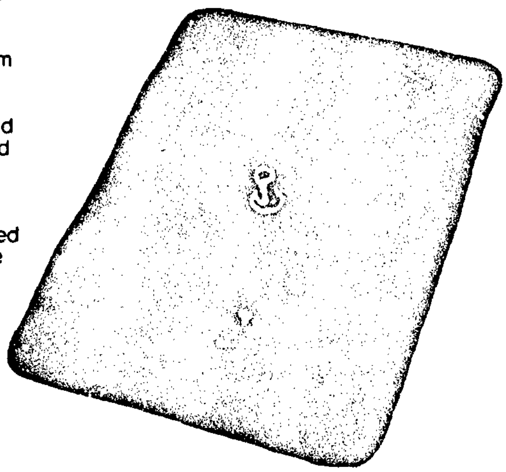
The bag is fully enclosed, except for a metal stem which gives access to the bag interior. Provided the tank is properly sealed air flows only in and out of the breather bag as the fluid level rises and falls. Thus all air and contaminants are prevented from contacting the fluid.

The standard breather bag is made from neoprene/nylon coated fabric, allowing prolonged contact with hydraulic fluid while resisting ozone cracking from contact with the atmosphere.

KleenVent Breather Bags are available:

- square
- rectangular
- sizes to fit most applications

See page 6 for ordering information.



INTERNAL BREATHER SYSTEM.

In this system, a Fawcett Breather Bag is fitted to the underside of the top of the fluid supply tank. The fluid occupies the full volume of the tank with the exception of breather bag interior, which is open to the atmosphere. Air is free to flow in and out of the breather bag as the oil volume changes. The bag has to be of sufficient size to accommodate the volume change within the tank, equal to the full system displacement, plus an additional 25% giving an allowance for any leakage and volume change due to thermal expansion or contraction.

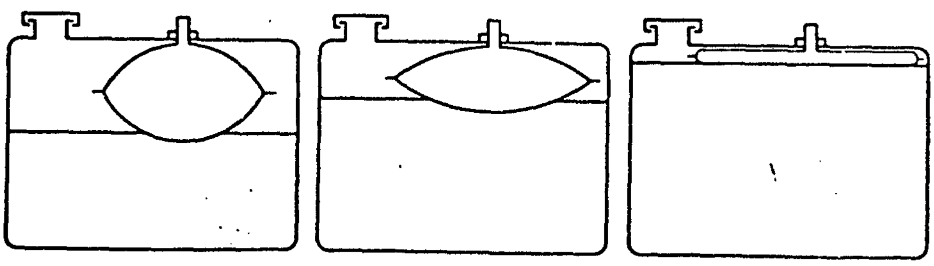


Figure 2.2-2 Hydraulic Reservoir Internal Bladder

Primarily, the internal bladder mitigates the engineering concern with respect to the space claim demands of the external bladder. Notably the bladder would be located within the hydraulic reservoir with the outside skin exposed to the oil and the inside skin exposed to the contaminated environment.

Secondly, using an internal bladder eliminates the need for a pressure valve and it's potential for contaminating the oil.

The primary tradeoffs between the internal and external bladders would be application of the pressure valve, space claim, weight growth, and decontamination efficiency.

To decontaminate, the bladder may be removed from the tank via an access port incorporated within the design of the hydraulic tank. The access port would be located above the maximum fluid level.

2.2.1 Producibility Concern. Though the technology for internal bladders exists, the bladders are no longer commercially available off-the-shelf, hence a bladder to fulfill the requirements of ATLAS would be a new design.

2.3 Filter. Filtration of the contaminated air is the classical approach to minimize ingestion of particles, particularly dust and dirt, within the hydraulic system on off-highway vehicles. For example, typical Pall filters provide a glass fiber medium to filter particles to 2.5 microns.

To address chemical and biological agents, a second, hydroscopic filter in series with the particle filter would be required to impede the chemical/biological agents. The filter would require changing after exposure to chemical and biological agents. Unfortunately, these agents would permeate through the filter with time.

2.4 Do Nothing. The do nothing approach would simply recognize that the hydraulic oil would be contaminated with each mission in a contaminated environment.

After each mission in which the oil became contaminated the hydraulic system would be drained, cleaned/flushed, and replenished with clean oil and filters at the intermediate maintenance level. Cleaning to decontaminate the components of the hydraulic system would either require complete disassembly to decontaminate or flushing the system. Flushing the system would require substantial volumes of oil to dilute the contaminants to "acceptable" levels. The volume of hazardous waste would increase. Maintenance personnel performing the decontamination procedure would in all probability be wearing protective clothing whose level of protection may be degraded upon contact with a petroleum product such a hydraulic oil.

The contaminated oil and filters would be classified as a hazardous waste necessitating proper disposal.

3.0 Recommendation Rationale.

The sealed hydraulic system with an internal bladder provides for the most cost effective solution. The external bladder and pressure valve space claim requirements compromise its desirability. Filtration provides only a "temporary" impediment to contamination of the system and would necessitates substantial logistic support. Doing nothing may result in unacceptable generation of hazardous waste and pose a safety problem during decontamination.

Though the internal bladder is not "commercially" available, the manufacturing technology is common and should be readily available from a variety of sources.

Attachment 5
Failure Modes

a) Electrical Short.

The presence of moisture or water will provide an electrical short circuit that induces a failure of that electrical circuit.

b) Fluid Contamination.

Contamination of various automotive fluids (engine, brake, and hydraulic oil, battery acid, coolants, etc.) by saltwater will alter the properties of that fluid and introduce the potential for failure.

c) Air Restriction/Constriction.

Salt water may impede the flow of air and impair the performance of the vehicle.

d) Galvanic Corrosion.

When two metals are placed in electrical contact and exposed to a conductive or corrosive solution, one tends to go into solution while the other acts as a cathode and does not go into solution. Galvanic corrosion can usually be predicted by referring to a table of standard electrode potentials.

Galvanic corrosion is accelerated when two metals in electrical contact have large differences in their electrode potentials. Parts may fail due to the accelerated attack when only one metal would have lasted much longer because of a uniform, but slow, attack. For instance, a steel hot water pipe may fail when a copper pipe is attached to it. Accelerated corrosion due to galvanic effects is usually greatest near the junction of the two metals. In addition, if the anodic material has a relatively small surface area compared with the cathode (small anode-large cathode), corrosion accelerates.

Galvanic corrosion may be prevented or minimized by:

1) avoiding electrical contact of two dissimilar metals by insulation
2) using metals having similar electrode potentials
3) avoiding large cathode/anode ratios of surface areas
4) designing for easy replacement, using thicker metal parts for anodic metals

Cathodic protection is making a metal part the cathode in a galvanic cell in order to prevent corrosion. This may be done by:

1) galvanizing steel
2) connecting magnesium to less active metals
3) impressing a current from an external power source

Underground pipes are frequently protected cathodically by 2) or 3). (Amphibious vehicles such as the USMC AAV7A1 are cathodically protected by 2.)

e) Stress Corrosion.
The presence of tensile stress and certain specific chemicals combine to cause stress corrosion, another insidious type of corrosion. Stress corrosion results in either transgranular (across grains) or intergranular cracking (along grain boundaries). Most of the surface of a stress-cracked metal is essentially unattacked. Stress cracking may occur at relatively low stress levels compared with stress needed for failure (tensile strength) and at relatively low concentrations of chemicals, such as C1 ions for austenitic stainless steels.

Stress corrosion of brass is frequently referred to as "season cracking". In the Tropics, brass cartridge cases cracked where the case was crimped to the bullet. Ammonia plus stress causes brass to stress crack. Carbon steel stress cracks in the presence of sodium hydroxide ("caustic embrittlement"), whereas austenitic stainless steels stress crack in chloride solutions.

Important variables are solution composition, temperature, and stress for a given metal. Stresses may be of several types:

1) residual stresses acquired during forming (stamping, rolling, etc.)
2) applied stresses resulting from the use of a structural part
3) thermal stresses, e.g., quenching or welding stresses

Corrosion products themselves can create stresses when a metal corrodes. The final cracking results from mechanical failure.

Although the mechanism of stress corrosion is not completely known, it appears that stresses generated from the presence of corrosion products plus stresses already present result in mechanical failure. Of course, the tips of cracks in metals are fairly sharp, and this may lead to accelerated corrosion. Plastic deformation occurs just ahead of the crack when it stops momentarily. Cracks grow sporadically—they have been heard even with the unaided ear. Rupture of passive films may also occur during stress cracking. In intergranular stress cracking such as occurs in brass, grain boundaries may be anodic compared with the grain interiors, and the grain boundaries are the preferred paths for cracking. The present state of knowledge about the mechanism of stress cracking leaves much to be discovered in the future.

Stress cracking may be reduced or prevented by:

1) decreasing the stress level by annealing, design, etc.
2) avoiding the environment that leads to stress cracking
3) changing the metal if the environment cannot be changed
4) adding inhibitors or applying cathodic protection to reduce the rate of corrosion.

f) Crevice.

Crevice corrosion is due to small volumes of stagnant solution collecting in crevices under bolts, under surface deposits such as dirt, corrosion products or loose paint, and in holes or under gaskets. Intense localized corrosion occurs when the crevice is wide enough to permit liquid entry, but sufficiently narrow to create a stagnant solution. Although this type of corrosion occurs in openings of about 10 to 100 mm, it rarely occurs (0.1 cm or larger). Fibrous gaskets are notorious for creating stagnant pockets in wide grooves or slots solutions on flanges. A surprising example of crevice corrosion is the fact that 304 stainless steel may be cut in two by placing a stretched rubber band around the stainless and immersing it in a chloride solution such as seawater.

The mechanism of crevice corrosion involves several steps:

1) *the depletion of oxygen in the stagnant solution due to corrosion of the metal [for example, O2 + 2Fe + 2H2O -> 2Fe(OH)x]*
2) *corrosion in the crevice continues through a reaction such as Fe - 2e- -> Fe+2; the electrons migrate through the metal to the region where oxygen is available: O2 + 2H2O + 4e- -> 4OH-*
3) *both chloride and hydroxide ions migrate into the crevice because of attraction by the cations created through corrosion, but chloride ions migrate more rapidly*
4) *the higher concentration of chloride ions causes corrosion to accelerate; also Fe+2 hydrolyzes to form a weak acidic solution: Fe+2 + 2H2O -> Fe(OH)2 + 2H+. This weak acid in conjunction with chlorides is highly corrosive.*

In crevice corrosion, there is often a long incubation period (as long as one year) before accelerated attack begins. Metals depending on passive oxide films are particularly susceptible to crevice corrosion because passivity may be broken by the presence of chlorides and acid of certain concentrations. Crevice corrosion may be minimized by avoiding crevices in design (e.g., using welded joints instead of bolts or rivets), by filling crevices with a sealant, by removing dirt and deposits regularly, and by using "solid" instead of fibrous gaskets.

Filiform corrosion is a special type of crevice corrosion in which corrosion occurs along channels under enameled or lacquered steel surfaces. Other metals have also exhibited filiform corrosion. The result of filiform corrosion is a network of 0.2-cm-wide worm-like trails of corrosion products. Corrosion trails move in straight lines, but they do not cross inactive trails; the active "head" reflects from the inactive trail and continues on its way. Filiform corrosion involves osmosis: water diffuses into the active head and out of the inactive tail because the head contains a high concentration of ferrous ions and the tail contains mainly precipitated ferric hydroxide. Thus, the filiform corrosion acts as a self-propagating crevice.

g) Pitting.

Pitting is another form of severe localized attack, and it results in holes in a metal, usually of small diameter. Pits frequently go undetected until the metal has been severely corroded because pits may be covered with corrosion products or by a protective coating having only a pinhole opening. Pitting is difficult to predict by laboratory tests, so it remains a particularly insidious form of corrosion.

Austenitic stainless steel containing 18% Cr and 8% Ni (18-8 type such as 304) may be pitted in sulfuric acid containing ferric chloride in only a few days. Pits usually take much longer to form, and they tend to grow in the direction of gravity. Pitting usually requires an incubation period of several months, but pitting corrosion accelerates once the pit forms because pit formation is autocatalytic. It is also similar to crevice corrosion. Once a pit begins to form, probably due to nonuniform local attack, the concentrations of both metal ions and hydrogen ions increase. Corrosion accelerates, and the pit corrodes because it is an anode. This services to protect the rest of the metal, which is an inactive cathode. Many systems that suffer from crevice corrosion are not susceptible to pitting corrosion on free surfaces, but metals that pit usually suffer from crevice corrosion as well. Electroplated coatings are particularly susceptible to pitting, e.g., automobile bumpers.

Pitting is frequently found in the presence of chloride ions and oxidizing agents such as Cu^{+2}, Fe^{+3}, or Hg^{+2}. It is often inhibited by hydroxides, chromates, or silicates. Surprisingly, carbon steel is more resistant to pitting than are stainless steels. Because chlorides and diluted acid accelerate pitting, these should be avoided. Addition of molybdenum to stainless steels markedly increases their resistance to pitting.

h) Erosion Corrosion.

Erosion corrosion is accelerated corrosion due to the relative motion of the metal and the environment. Mechanical wear and abrasion are involved, in addition to corrosion. Metal may corrode, forming dissolved ions, which are swept away, or it may form solid corrosion products, which are mechanically removed.

Erosion corrosion appears as grooves, gullies, waves, or valleys and is usually directional in character. This type of corrosion may occur in a surprisingly short time, particularly when static corrosion tests are relied on. Obviously, metals that depend on the presence of passive oxide, or other surface films, are susceptible to erosion corrosion due to the continual destruction or damage of these protective films. Soft metals, such as lead and copper, are easily affected by erosion corrosion.

Moving fluids cause erosion corrosion in components of piping systems (bends, elbows, tees), valves, pumps, blowers, propellers, impellers, agitated vessels, tubing in heat exchangers, turbine blades and nozzles, ducts, cutters, grinders, and so on. Velocity of the moving fluid and its composition play important roles in erosion corrosion. Metals having good inherent corrosion resistance, rather than metals depending on passive surface films, exhibit good erosion corrosion resistance. Addition of another metal to an alloy usually improves erosion corrosion characteristics due to the formation of more resistant surface films.

Erosion corrosion may be reduced or avoided by:

1) *using materials with better inherent corrosion or erosion corrosion resistance*
2) *designing to avoid high-velocity flow of liquids or sharp changes in direction of liquid flow*
3) *changing the environment, such as by deaeration, addition of corrosion inhibitors, or removal of solids by filtration,*
4) *coatings such as hard facings or overlays*
5) *cathodic protection*

Cavitation damage is the formation and collapse of vapor bubbles in a liquid adjacent to a metal surface. When vapor bubbles burst, shock waves form and cause damage to the metal, particularly by the destruction of passive surface films. Cavitation damage can be reduced by designing to minimize hydrodynamic pressure differences. Coating metals with resilient rubber or plastic can often minimize damage.

Fretting corrosion occurs at contact areas between metals subjected to vibration or slip. Pits or grooves appear in the metal and are surrounded by corrosion products. Fretting corrosion is sometimes referred to as friction oxidation, wear oxidation, or chafing. This type of corrosion occurs in the atmosphere rather than in aqueous solutions. Seizing and galling frequently occur, as well as fatigue fracture and loss of tolerances.

Examples of fretting corrosion include bolted tie plates on train rails and press-fitted ball-bearing races on shafts. In order for fretting corrosion to occur, the interface must be under stress, relative motion between two surfaces must occur such as in vibration motion, and the stress and motion must be great enough to deform the surfaces.

The mechanism for fretting corrosion may involve either:

1) *cold welding occurring between the relatively few contact points between the two surfaces followed by rupture of the contact points and removal of debris, which immediately oxidize because they are so finely divided*
2) *rupture of protective oxide layers at contact points followed by reoxidation of the freshly exposed metal.*

Fretting corrosion may be reduced or eliminated by:

1) *lubrication with oil or grease*
2) *increasing the hardness and, therefore, the abrasion resistance of one or both metal surfaces*
3) *using gaskets to absorb vibration and exclude oxygen*
4) *increasing the relative motion of the two metal parts*

i) Uniform Corrosion.

Uniform corrosion is the most common form of corrosion. Uniform attack occurs when an electrochemical reaction, or solution reaction, proceeds uniformly over the entire surface of a metal. A sheet of steel exposed to the environment exhibits uniform attack. Because the corrosion rate is easily predicted from corrosion test data, it is relatively easy to deal with uniform corrosion. In some instances, very slow attack may be tolerated. In other cases, it is even desirable, such as in steels made so that the corrosion product is both tightly adherent and decorative (for instance, Cor-Ten steel rusts to form a highly protective surface oxide, and this surface oxide is esthetically pleasing; hence, unpainted architectural panels, bridges, etc., are made from this steel).

Uniform corrosion may be controlled by using proper materials, inhibitors, or cathodic protection. Uniform corrosion is the least insidious type of corrosion because it is completely predictable.

j) Intergranular.

Grain boundaries have a higher energy than the interiors of crystals. However, the surface energy of a metal is still higher, so grain boundaries generally do not corrode as rapidly as the surface. However, in certain circumstances the grain boundaries are far less corrosion resistant than the grain interiors, and intergranular corrosion, in which grain boundaries corrode but grain interiors do not, results.

Intergranular corrosion is caused by impurities collected at grain boundaries or by enrichment or depletion of elements in and near the grain boundaries. Iron tends to segregate along grain boundaries in aluminum. Other examples of grain boundary enrichment include zinc in brass and iron in stainless steels.

Intergranular corrosion occurs in 18-8 stainless steels (e.g., type 304) when they have been sensitized by heating in the range 500 degree C to 800 degree C. Sensitization is the precipitation of chromium carbide, Cr23C6, in the grain boundaries. This results in depletion of chromium in a narrow zone parallel with the grain boundaries. The depleted zone then corrodes much more easily and rapidly than the bulk alloy. The time and temperature are critical for sensitization to occur. At temperatures greater than 800 degree C, sensitization does not occur because Cr23C6 will not precipitate. Below 500 degrees C, the diffusion rate of carbon is too low for Cr23C6 to form at grain boundaries. The time in the range 510 degree C to 790 degree C must be sufficient for carbon to diffuse to the grain boundaries to precipitate chromium carbide, but not long enough for chromium to diffuse in from the interior of the grain to replenish the depleted zone.

The complicated time-temperature dependence results in a zone of corrosion occurring parallel to welds of austenitic stainless steels. The band near the weld has experienced the proper time-temperature history to cause sensitization, which later results in corrosion. Intergranular corrosion that occurs as a result of welding stainless steels is called weld decay.

Intergranular corrosion in austenitic stainless steels may be avoided by:

1) *heat treating at a temperature above 800 degree C and cooling rapidly to avoid sensitization; the high-temperature treatment dissolves any carbides that may be present, and rapid cooling prevents their subsequent formation at grain boundaries*
2) *lowering the carbon content of the stainless steel to below 0.03%; this decreases the quantity of chromium carbide precipitated so that only minor amounts of chromium are depleted from near grain boundaries*
3) *adding elements such as niobium or titanium to the stainless steel, because these metals preferentially react with carbon to form insoluble carbides throughout the steel; there is no carbon left for a subsequent reaction with chromium.*

These latter steels are called titanium- or niobium-stabilized. Titanium-stabilized stainless steel is 321, while niobium-stabilized is type 347.

k) Selective Leaching.

Selective leaching is the preferential removal of one metal from a solid solution as a result of corrosion. The most common example is the dezincification of brass, in which zinc is preferentially removed from containing 30% or more Zn. The color of brass becomes redder and less yellow brasses during dezincification. Two types of dezincification are:

1) *uniform or layer-type, in which the whole surface layer is depleted of zinc*
2) *plug-type, in which dezincification is confined to pit-like regions, usually in brasses containing lower zinc contents.*

The aftermath of dezincification is porous copper-rich alloy, which is weak and permeable.

The mechanism for dezincification appears to be solution of brass, followed by deposition of copper, leaving zinc in solution. Dezincification may be reduced or eliminated by:

1) reducing the oxidizing power of the environment
2) cathodic protection
3) using brass containing a lower level of zinc

Graphitization of gray cast iron is the corrosion of iron, which leaves a weak network of graphite and corrosion products. Dimensional changes do not occur, and failure can be dramatic. This is corrosion of a two-phase structure and is not really analogous to dezincification, which involves a single solid phase.

CATERPILLAR®

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October 1991

Parts Manual

RT80 RT100 Telescopic Material Handler

1GJ1-Up (Vehicle)
2FG1-Up (Engine)
3WE1-Up (Transmission)

Powered by 3114 Diesel Engine

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October 1991

RT80 RT100
Telescopic Material Handler

1GJ1-Up (Vehicle)
2FG1-Up (Engine)
3WE1-Up (Transmission)

TECHNICAL INFORMATION DIVISION
MARKETING SUPPORT SERVICES

LIFT TRUCK IDENTIFICATION

Caterpillar lift trucks are identified with SERIAL NUMBERS and ARRANGEMENT NUMBERS. In some cases MODIFICATION NUMBERS are also used. These numbers are shown on the serial number plate mounted on the cowling.

Caterpillar dealers need all of these numbers to determine which components were included on the machine when it was assembled at the factory. This permits accurate identification of replacement part numbers.

ORDERING PARTS

Quality Caterpillar Replacement parts are available from Caterpillar dealers throughout the world. Their parts stocks are up to date and include all parts normally required to protect your investment in Caterpillar lift trucks. Some dealers may have exchange/remanufactured parts available as an option. When ordering parts, your order should specify the quantity, part number, part name and the serial number, arrangement number and modification number of the machine for which the parts are needed. If in doubt about the part number, please provide your dealer with a complete description of the needed item.

HOW TO USE THE PARTS BOOK

Caterpillar Parts Books include illustrations of the groups or assemblies which make up the machine. These illustrations show the standard components and attachments for each machine.

The alphabetical index located in the front part of the book should be used to determine the page number on which specific illustrations are shown. Reference to those pages will identify each of the individual serviceable parts.

Captions

The caption under each illustration identifies the part number and name of the group or assembly shown. If more than one illustration is included for any group, the caption identifies the specific serial numbers to which each illustration applies. In some cases it is not possible to determine the specific serial numbers to which different illustrations are applicable. In those cases the caption identifies the illustration as "First Type", "Second Type", etc. Reference to the actual group or assembly is necessary in those cases to determine which illustration should be used. Captions provide additional information such as page numbers where illustrations of sub assemblies are shown, information regarding quantities used and other information intended to assist the user in determining parts needs.

Indented Part Names

Within each illustration is a parts list identifying each serviceable part in the illustration. When a part name is indented in this list, it means that serviceable item is a part of the serviceable item under which it is indented.

Abbreviations

O.D.	Outside diameter
I.D.	Inside diameter
A	Not Part of This Group
B	Use as Required
C	Indicates Change
D	Order by the Meter
E	Order by the Centimeter
F	Not Shown
G	Order by the Inch
I	See Hose Fabrication Guide
K	See Mast Arrangement
M	Metric Part
R	Remfg Part May Be Available
X	Major Component Exchange
Y	Separate Illustration
Z	Not Serviced Separately

REMANUFACTURED COMPONENTS

As an option when making repairs consider Caterpillar Remanufactured Components. Components that are available through the Caterpillar Remanufactured Program are identified three ways in the parts book:

- with the letter R in the note field of the parts list
- with an R* at the beginning of the first line of the caption
- with an *R at the end of the first line of the caption

Check with your local Caterpillar Dealer for the availability of Remanufactured Components.

NOTE:

Continuing improvement and advancement of product design may cause changes to your machine which may not be included in this publication.

Whenever a question arises regarding your Caterpillar product, or this publication, please consult your Caterpillar dealer for the latest available information.

ENTIFICATION DU CHARIOT ÉLÉVATEUR

s chariots élévateurs Caterpillai portent un NUMÉRO DE RIE et un NUMÉRO DE VERSION. Dans certains cas, :S NUMÉROS DE MODIFICATION sont également uti- ›s. Ces numéros figurent sur la plaque signalétique qui trouve sur le capotage.

s concessionnaires Caterpillar doivent connaître tous s numéros pour savoir quels composants ont été em- ›yés lors du montage en usine et trouver plus facilement numéro des pièces de rechange.

)MMANDE DE PIÈCES

s concessionnaires Caterpillar fournissent dans le ›nde entier des pièces de rechange de qualité Caterpillar. ırs stocks de pièces sont constamment réapprovi- nnés et comptent toutes les pièces nécessaires pour surer la bonne marche de votre chariot élévateur terpillar. Certains concessionnaires proposent égale- nt des pièces en échange standard ou rénovées, au ›ix. Lors des commandes de pièces, mentionner la antité, le numéro et la désignation des pièces ainsi que le néro de série, le numéro de version et, le cas échéant, le néro de modification du chariot auquel les pièces sont stinées. En cas de doute sur le numéro de pièce, fournir concessionnaire une description complète de la pièce en estion.

'ILISATION DU CATALOGUE DE PIÈCES

: Catalogues de pièces Caterpillar comportent des illus- ions des groupes ou ensembles qui composent la ma- ıe. Ces illustrations représentent les composants stan- d et nombre des accessoires disponibles.

début du catalogue figure un index alphabétique qui voie aux pages et illustrations correspondantes. Toutes pièces du moteur avec leur numéro figurent dans ces jes.

jendes

ıque illustration comporte une légende comprenant le ıéro de pièce et la désignation du groupe ou celle de semble. Si à un groupe donné correspondent plusieurs trations, la légende indiquera le numéro de série de que machine spécifique. Parfois, il n'est pas possible de oir à quels numéros de série spécifiques de la machine apportent les différentes illustrations. Dans ce cas, les ›ndes comportent la mention "Premier type", "Deuxième e", etc. Pour déterminer quelles illustrations utiliser, il dra connaître la référence du groupe ou de l'ensemble espondant. Les légendes indiquent également les nu- os de page des plans des sous-ensembles, les quantités utilisées et autres renseignements destinés à aider l'utilisateur à déterminer quelles sont les pièces nécessaires.

Désignations de pièces en retrait

Chaque illustration comporte la liste des pièces qui la constituent et que l'on peut se procurer. Lorsqu'une désignation de pièce est en retrait, cela veut dire que l'article en regard fait partie de l'ensemble sous lequel il figure.

Abréviations et symboles

O.D.	Diamètre extérieur
I.D.	Diamètre intérieur
A	Ne fait pas partie de ce groupe
B	Utiliser selon besoin
C	Modification
D	Commander par mètre
E	Commander par centimètre
F	Non représenté
G	Commander par pouce
I	Flexible XT
K	Voir version de mât
M	Pièce métrique
R	Pièce rénovée éventuellement disponible
X	Echange standard
Y	Illustration séparée
Z	Non fourni séparément

PIÈCES RÉNOVÉES

En cas de réparations, tenir également compte de la disponibilité de certains composants Caterpillar rénovés. Dans le présent catalogue, ces pièces rénovées sont identifiées de trois manières:

–par la lettre R dans la colonne Nota de la liste de pièces

–par la lettre R* au début de la première ligne de la légende

–par la lettre *R à la fin de la première ligne de la légende

Pour savoir si une pièce rénovée est disponible, consulter le concessionnaire Caterpillar.

NOTA:

En raison du progrès technique et des améliorations continuelles apportées au matériel, votre machine comporte peut-être des modifications qui n'apparaissent pas dans la présente publication.

En cas de doute sur un détail de votre machine Caterpillar ou sur le texte de la présente publication, adressez-vous à votre concessionnaire Caterpillar.

MONTACARGAS

Los montacargas Caterpillar se identifican con NUMEROS DE SERIE y NUMEROS DE DISPOSICION. En algunos casos se usan también NUMEROS DE MODIFICACION. Estos números se muestran en la placa de número de serie que se encuentra en el cubretablero.

Los distribuidores Caterpillar necesitan estos números para determinar con qué componentes se armó la máquina en la fábrica. Esto permite una identificación exacta de los números de pieza de repuesto.

COMO PEDIR REPUESTOS

Piezas de repuesto Caterpillar de calidad están disponibles de los distribuidores Caterpillar en todo el mundo. Sus existencias actualizadas incluyen todas las piezas normalmente requeridas para proteger su inversión en montacargas Caterpillar. Algunos distribuidores pueden tener piezas remanufacturadas de intercambio, disponibles como opción. Al pedir piezas de repuesto, especifique en su pedido la cantidad, el número de pieza, el nombre de la pieza, el número de serie, el número de disposición y el número de modificación de la máquina para la cual se necesitan las piezas. Si tiene duda del número de pieza, déle al distribuidor una descripción completa de la misma.

COMO USAR ESTE CATALOGO

Los Catálogos de Piezas Caterpillar tienen ilustraciones de los grupos o conjuntos que componen la máquina. Estas ilustraciones muestran los componentes estándar y muchos de los accesorios disponibles para la máquina.

Se debe utilizar el índice alfabético al frente de este catálogo para determinar el número de página donde se encuentran ilustraciones específicas. Dichas páginas identifican las piezas utilizables.

Títulos

El título debajo de cada ilustración identifica el número de pieza y el nombre del grupo o del conjunto indicado. Si se incluye más de una ilustración de cualquier grupo, el título identifica números de serie de las máquinas correspondientes a cada ilustración. En algunos casos no es posible determinar los números de serie de las máquinas correspondientes a las diferentes ilustraciones. En esos casos, el título identifica la ilustración como "Primer tipo", "Segundo tipo", etc. Es necesario referirse al grupo o conjunto en sí para determinar cuál ilustración se debe utilizar. Los títulos proveen información adicional: los números de las páginas en que aparecen las ilustraciones de los subconjuntos, las cantidades utilizadas y demás información para ayudar al usuario a determinar las piezas necesarias.

Nombres de Pieza sangrados

En cada ilustración hay una lista de piezas que identifica las piezas utilizables en la ilustración. Cuando el nombre de una pieza está sangrado en esta lista, significa que esta pieza forma parte de la pieza utilizable inmediatamente arriba.

Abreviaturas y simbolos

O.D.	Diámetro exterior
I.D.	Diámetro interior
A	No es pieza de este grupo
B	Utilizado según la demanda
C	Indica cambio
D	Se pide por metro
E	Se pide por centímetro
F	No se muestra
G	Se pide por pulgada
I	Manguera XT
K	Ver el mástil
M	Pieza métrica
R	Puede estar disponible como pieza remanufacturada
X	Puede ser posible el intercambio de Componentes Principales
Y	Ilustración separada
Z	No se suministra por separado

COMPONENTES REMANUFACTURADOS

Al hacer reparaciones tenga en cuenta la disponibilidad de componentes remanufacturados Caterpillar. Dichos componentes se identifican de tres maneras en este catálogo de piezas:

- con la letra R en la columna de Nota de la lista de piezas
- con la letra R* al comienzo de la primera línea de la leyenda
- con la letra *R al final de la primera línea de la leyenda

Para saber si un componente remanufacturado está disponible, consulte a su distribuidor Caterpillar.

NOTA:

Las continuas mejoras y adelantos en diseño podrían originar cambios a su máquina que no se incluyan en esta publicación.

Cuando tenga alguna pregunta acerca de su producto Caterpillar o de esta publicación, consulte al distribuidor Caterpillar para obtener la información más reciente.

L'IDENTIFICAZIONE DEL CARRELLO ELEVATORE

L'identificazione dei carrelli elevatori Caterpillar avviene tramite il NUMERO DI SERIE ed il NUMERO DEL TIPO DI ALLESTIMENTO. In alcuni casi viene usato anche il NUMERO DELLA MODIFICA. Questi numeri sono stampigliati sulla targa di identificazione applicata al cofano.

Tutti questi numeri sono necessari ai dealer Caterpillar per poter determinare quali componenti sono stati impiegati nell'assemblaggio in fabbrica della macchina. Ciò rende possibile l'esatta identificazione dei numeri delle parti di ricambio.

COME ORDINARE I RICAMBI

I ricambi originali Caterpillar sono disponbili presso la rete internazionale di dealer Caterpillar. I magazzini dei dealer sono sempre aggiornati e sono provvisti di tutti i ricambi di normale consumo, necessari per proteggere il vostro investimento in carrelli elevatori Caterpillar. Molti dealer offrono anche gruppi completi in Programma Scambio o componenti ricostruiti da Caterpillar, affinché il cliente possa segliere l'alternativa più conveniente. Nelle ordinazioni di ricambi è necessario indicare quantità, numero e nome del ricambio, nonché il numero di serie, del tipo di allestimento e della modifica della macchina per la quale tali ricambi sono richiesti. In caso di dubbio relativo al numero del ricambio è opportuno fornire al dealer una completa descrizione del comonente a cui ci si riferisce.

COME USARE IL CATALOGO RICAMBI

I cataloghi ricambi Caterpillar illustrano i gruppi completi ed i sottogruppi che formano la macchina, ne visualizzano sia i componenti standard, sia anche alcuni degli accessori disponibili per la macchina.

L'indice alfabetico riportato all'inizio del catalogo deve essere usato per la ricerca del numero di pagina nella quale si possono trovare le singole illustrazioni specifiche. La consultazione di queste pagine consente l'identificazione di ciascun componente separatamente disponibile.

Leggende

La leggenda al piede di ciascuna illustrazione identifica il numero del ricambio ed il nome del gruppo o sottogruppo illustrato. I numeri di ricambio per gruppi completi sono riportati a titolo indicativo. Per conoscere la disponibilità di gruppi completi è opportuno sentire il vostro dealer CAT. Se per il medesimo gruppo esiste più di una illustrazione la leggenda identifica i numeri specifici di serie delle macchine a cui ciascuna illustrazione si riferisce. In alcuni casi non è possibile stabilire i numeri specifici di serie delle macchine alle quali le diverse illustrazioni possono essere attribuite.

In questi casi la leggenda identifica l'illustrazione come "Tipo 1" - "Tipo 2", ecc. In queste condizioni è necessario confrontare le illustrazioni con il gruppo completo, o con il sottogruppo, da sostiituire. La leggenda fornisce anche altre informazioni, come i numeri delle pagine nelle quali appaiono le illustrazioni dei sottogruppi, le quantità utilizzate ed alter notizie utili per assistere il cliente nella selezione dei ricambi occorrenti.

Nomi di Ricambi Fuori Colonna

All'interno di ogni illustrazione c'è un elenco dei ricambi che fanno parte del gruppo. Quando, in questa lista, il nome di un ricambio è stampato fuori colonna ciò indica che è un componente dell'assieme precedente soprastante.

Abbreviazioni

O.D.	Diametro esterno
I.D.	Diametro interno
A	*No fa parte di questo gruppo*
B	*Da impiegare secondo necessità*
C	*Indica un cambiamento*
D	*Si ordina a metraggio*
E	Si ordina per centimetri
F	No illustrato
G	Si ordine per pollici
I	*Complessivo tubi flessibili CAT-XT*
K	*Vedere composizione montante*
M	Particolare costruito con misure metriche
R	Possibile disponibilità componente ricostruito
X	Gruppo in Programma Scambio
Y	Illustrato separatamente
Z	No viene fornito separatamente

COMPONENTI RICOSTRUITI

Quando eseguite una riparazione prendete in considerazione l'uso di componenti ricostruiti da Caterpillar. Nel catalogo ricambi questi particolari sono così identificati:

- Con la lettera "R" nella colonna "NOTE" dell'elenco ricambi
- *Con la lettera "R*" all'inizio della prima riga della leggenda*
- *Con la lettera "*R" alla fine della prima riga della leggenda.*

Sentite il vostro dealer Caterpillar in merito alla disponibilità di componenti ricostruiti.

AVERTENZA

Il costante perfeizionamento progettuale dei nostri prodotti può comportare modifiche già introdotte nella vostra macchina, ma non ancora incluse in questo catalogo ricambi.

Per qualisiasi domanda che riguardi il vostro prodotto Caterpillar o questo catalogo vi preghiamo di rivolgervi direttamente al vostro dealer Caterpillar che vi darà le informazioni più aggiornate.

GABELSTAPLERKENNZEICHNUNG

Cat-Gabelstapler sind mit SERIAL NUMBERS und ARRANGEMENT NUMBERS (Serien-Nr. und Ausrüstungs-Nr.) gekennzeichnet. In einigen Fällen werden auch MODIFICATION NUMBERS (Änderungsnummern) verwendet. Diese Nummern befinden sich auf dem Typenschild an der Motorhaube.

Die Cat-Händler benötigen alle genannten Nummern, um feststellen zu können, welche Baugruppen bei der Montage des Geräts im Werk eingebaut wurden. Nur mit Hilfe dieser Angaben lassen sich die Bestellnummern der benötigten Ersatzteile genau bestimmen.

BESTELLEN VON ERSATZTEILEN

Original-Cat-Ersatzteile können bei den Cat-Händlern überall auf der Welt bestellt werden. Ihre umfangreichen Lager enthalten normalerweise alle Teile, die Sie für Ihren Cat-Gabelstapler benötigen. Einige Händler bieten Reparatursätze, Austausch- oder werküberholte Teile an, so daß Sie die Auswahl unter verschiedenen Reparaturmöglichkeiten treffen können. Ihre Bestellung muß folgende Angaben enthalten: Anzahl der benötigten Teile, Bestellnummer, Bezeichnung des Teils; Serien-Nr., Ausrüstungs-Nr. und Änderungs-Nr. des Geräts, für das die Teile benötigt werden. Wenn Sie Zweifel hinsichtlich der richtigen Bestell-Nr. haben, geben Sie dem Händler eine möglichst genaue Beschreibung des benötigten Teils.

HINWEISE ZUR BENUTZUNG DES PARTS BOOKS

Die Cat-Parts Books enthalten Zeichnungen der Gruppen oder Teile des Geräts. Gezeigt werden die Standardteile sowie verschiedenes Zubehör für die Geräte.

Anhand des Index vorn im Buch können Sie die Nummer der Seite heraussuchen, auf der sich die von Ihnen gesuchte Abbildung befindet. Beim Aufschlagen der betreffenden Seite können dann alle gesuchten Teile identifiziert werden. Hinten im Buch befindet sich ein numerischer Index, mit allen Bestell-Nr. und dem Hinweis auf die Seite, auf der sich die entsprechenden Zeichnungen befinden.

Bildunterschriften

Die Zeilen unter jeder Abbildung enthalten die Bestell-Nr. der gezeigten Baugruppen. Die Nummer wird nur als Referenz aufgeführt. Ihr Cat-Händler kann Ihnen sagen, ob eine Gruppe komplett lieferbar ist. Wenn für eine Gruppe mehrere Zeichnungen vorhanden sind, enthalten die Zeilen unter den Zeichnungen die Seriennummern, denen jede Zeichnung entspricht. In einigen Fällen ist es nicht möglich, die Serien-Nr. anzugeben, auf die sich die Zeichnungen beziehen. In diesem Fall wird lediglich First Type (Typ 1), Second Type (Typ 2) usw. angegeben. Hier ist ein Hinweis auf die Baugruppe erforderlich, um anzuzeigen, welche Abbildung verwendet werden muß. Die Zeilen unter den Abbildungen enthalten ferner Angaben über die Seiten, auf denen sich Zeichnungen von Unterbaugruppen und Anzahl der benötigten Teile sowie andere Angaben befinden, die es dem Benutzer des Buchs erleichtern, die gewünschten Teile zu identifizieren.

Eingerückte Bezeichnungen

In der zu jeder Abbildung gehörenden Ersatzteilliste sind manche Bezeichnungen eingerückt. Dadurch wird angezeigt, daß das entsprechende Teil zu dem gehört, unter dessen Bezeichnung es eingerückt ist.

Abkürzungen und Symbole

O.D.	Außendurchmesser
I.D.	Innendurchmesser
A	kein Teil dieser Gruppe
B	nach Bedarf verwenden
C	Hinweis auf eine Änderung
D	in Meter-Länge bestellen
E	in Zentimeter-Länge bestellen
F	nicht gezeigt
G	in Zoll-Länge bestellen
I	XT-Schlauch
K	siehe Mast-Ausrüstung
M	metrisches Teil
R	werküberholtes Teil unter Umständen lieferbar
X	Austauschteil
Y	separate Abbildung
Z	nicht einzeln erhältlich

WERKÜBERHOLTE BAUGRUPPEN

Beim Durchführen von Reparaturen sollte auch die Verwendung von werküberholten Baugruppen in Betracht gezogen werden. Derartige Teile sind im Parts Book auf drei verschiedene Arten gekennzeichnet:

- durch den Buchstaben R in der Spalte "NOTE" der Ersatzteilliste;
- durch "R*" zu Beginn der ersten Zeile der Bildunterschrift;
- durch "*R" am Ende der ersten Zeile der Bildunterschrift.

Erkundigen Sie sich bei Ihrem Cat-Händler nach der Verfügbarkeit von werküberholten Teilen.

ANMERKUNG:

Ständig vorgenommene Verbesserungen und Weiterentwicklungen an Ihrem Gerät können Änderungen verursachen, die in der vorliegenden Ausgabe noch nicht berücksichtigt sind. Sie werden jedoch in später folgenden Ausgaben erscheinen.

Fragen zu Ihrem Cat-Gerät oder diesem Ersatzteilbuch beantwortet Ihr Cat-Händler.

MAINTENANCE PARTS

DESCRIPTION	PART NO.	PAGE NO.
BREATHER	9G5127	80
BREATHER AS	2W9162	33
ELEMENT AS (PRIMARY)	7W3920	42
ELEMENT AS-SECONDARY	7C1062	42
ELEMENT-FILTER	5T9054	92
FILTER AS-FUEL	1R0711	57
FILTER AS-OIL	1R0714	30
REGULATOR-TEMP	9Y3365	37
V-BELT	618384 9L1553	39 23

REMANUFACTURED COMPONENTS

As an option when making repairs consider Caterpillar Remanufactured Components. Components that are available through the Caterpillar Remanufactured Program are identified three ways in the parts book:

- with the letter R in the note field of the parts list
- with an R* at the beginning of the first line of the caption
- with an *R at the end of the first line of the caption

Typical components included in the Remanufacturing Program include:

ALTERNATORS
CONNECTING RODS
CRANKSHAFTS - UNDERSIZE
CRANKSHAFTS - UPGRADE TO NEW
CYLINDER HEADS
ELECTRONIC CONTROL MODULES (ECM)
ELECTRONIC SENSORS
FUEL INJECTORS
FUEL NOZZLES
FUEL PUMPS
GOVERNORS
OIL PUMPS
PISTONS
SHORT BLOCKS
STARTERS
TURBOCHARGERS - COMPLETE
TURBOCHARGER CARTRIDGES
WATER PUMPS

Caterpillar Remanufactured engines for many engine arrangements are also available.

MAJOR COMPONENT EXCHANGE

As an option when making repairs consider Caterpillar Major Component Exchange Program. Components included in this program are noted in the parts book with an *X at the end of the first line of the caption.

Typical components include:

ENGINES
PISTON TYPE HYDRAULIC MOTORS
PISTON TYPE HYDRAULIC PUMPS
SHORT BLOCKS
TRANSMISSIONS
TORQUE CONVERTERS
STEERING BRAKE AND CLUTCH

Check with your local Caterpillar Dealer for the availability of Remanufactured Components and Major Component Exchanges.

INDEX 1

ENGINE ARRANGEMENT

BASIC ENGINE

LUBRICATION SYSTEM

COOLING (ENGINE)

AIR INLET AND EXHAUST SYSTEM (ENGINE)

FUEL (ENGINE)

ELECTRICAL SYSTEM (ENGINE)

ENGINE RELATED PARTS

TRANSMISSION AND DRIVETRAIN

INDEX 2

AXLES AND BRAKES

STEERING SYSTEM

HYDRAULIC SYSTEM

FRAME AND PANELS

INDEX 3

BOOM AND FORKS

CAB

ELECTRICAL EQUIPMENT

DECALS

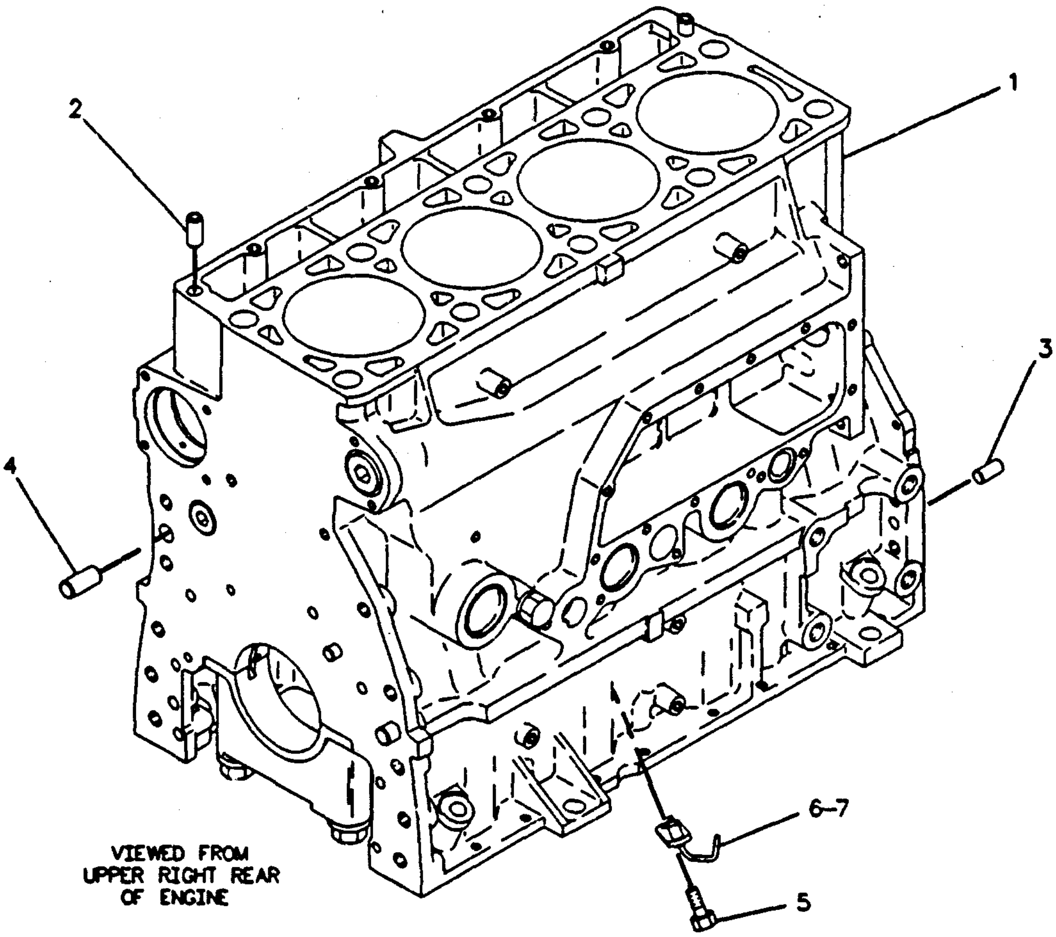
ENGINE ARRANGEMENT

497494 P

ENGINE ARRANGEMENT

497494 P

BASIC ENGINE



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7E5311	1	CYLINDER BLOCK GP					
	2	1W8407	2	SLEEVE					
	3	6V3538	2	DOWEL					
	4	7N5683	2	DOWEL					
	5	6V3940	4	BOLT					
	6	7C2171	4	TUBE AS-COOLING JET (EACH INCLUDES)					
	7	2F3124	1	DOWEL					
		7C6208	1	SLEEVE-CYLINDER FOR SALVAGE OF DAMAGED CYL. BORES IN BLOCK QUANITY TO BE DETERMINED BY USER.					

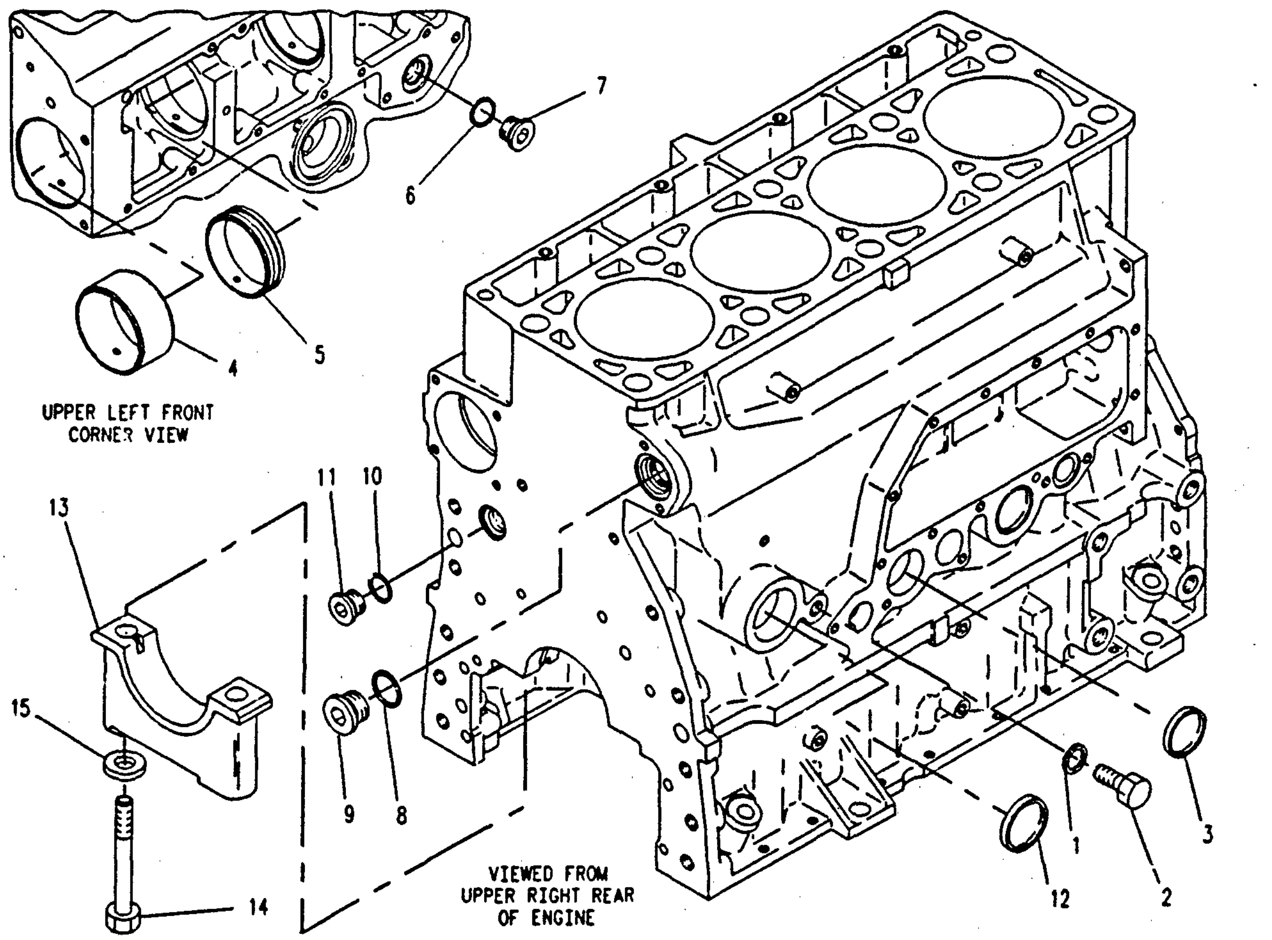
NOT PART OF THIS GROUP
CHANGE FROM PREVIOUS TYPE
NOT SHOWN

M-METRIC PART
Y-SEPARATE ILLUSTRATION

F-497392 EP

4W3724 CYLINDER BLOCK GP
7E5311-Page 5

BASIC ENGINE



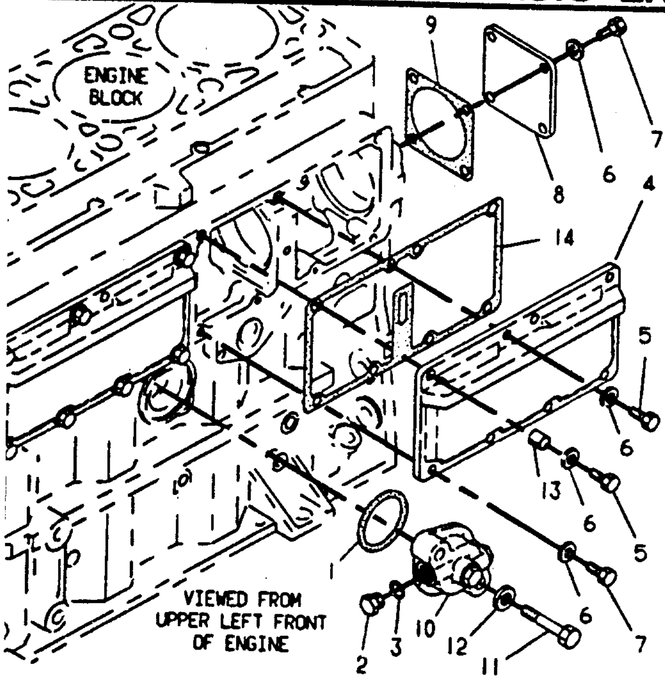
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6F7062	1	WASHER					
M	2	8T0293	1	BOLT					
	3	2M6471	2	PLUG-CUP					
	4	2W7211	1	BEARING-SLEEVE					
	5	2W7213	4	BEARING-SLEEVE					
	6	3K0360	1	SEAL-O-RING					
	7	9S8005	1	PLUG-O-RING					
	8	3D2824	1	SEAL-O-RING					
	9	9S8008	1	PLUG-O-RING					
	10	2M9780	1	SEAL-O-RING					
	11	9S8006	1	PLUG-O-RING					
	12	3H5552	1	PLUG-CUP					
	13	7E2968	5	CAP-CRANKSHAFT BEARING					
M	14	6V7675	10	BOLT					
	15	5P8247	10	WASHER-HARD					

M-METRIC PART

F-497409 EP

7E5311 CYLINDER BLOCK GP
Part Of 4W3724 Cylinder Block

BASIC ENGINE



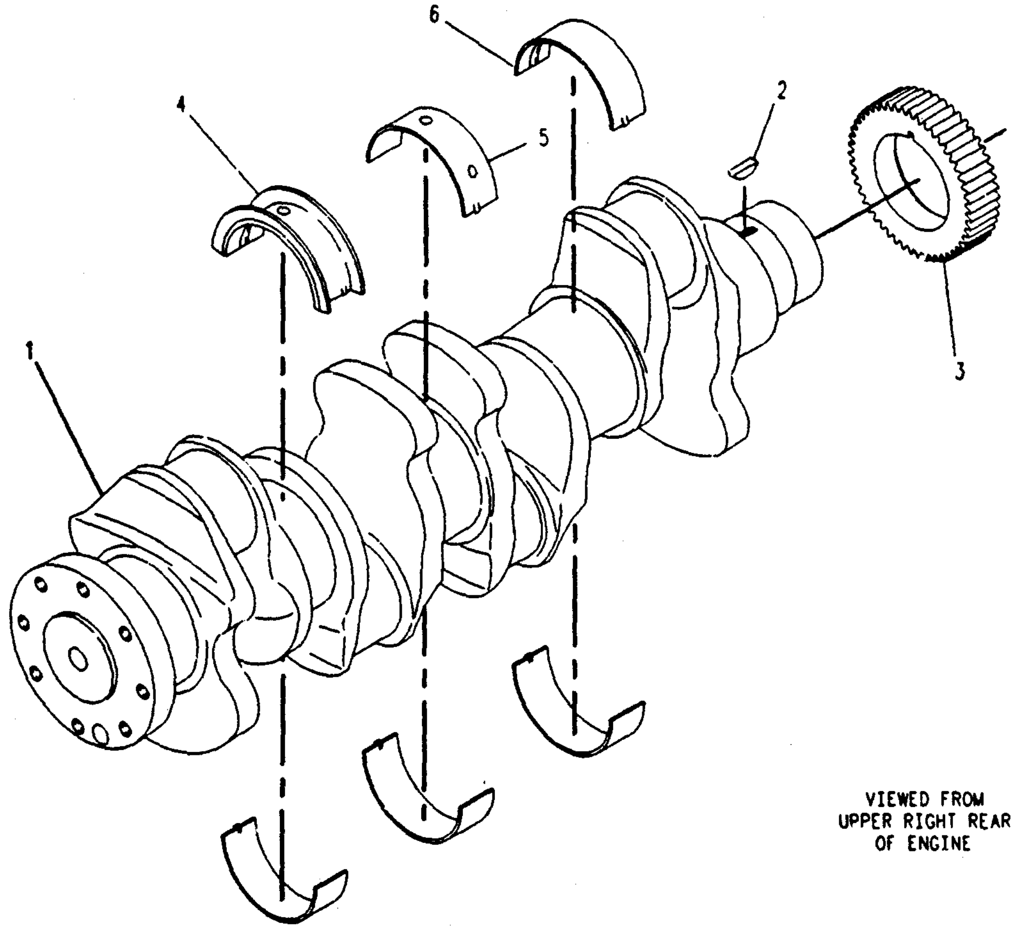
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	4F9653	1	SEAL-O-RING
	2	9S4191	3	PLUG-O-RING
	3	3J1907	3	SEAL-O-RING
	4	7W3871	2	COVER-SIDE
M	5	6V2317	7	BOLT
	6	9M1974	19	WASHER
M	7	6V5217	12	BOLT
	8	2W6544	1	COVER
	9	7W2426	1	GASKET
	10	9Y0747	1	MANIFOLD-OIL
M	11	6V5842	2	BOLT
	12	6V5839	2	WASHER
	13	7W3872	4	SLEEVE
	14	7W9699	2	GASKET

M-METRIC PART

A-457072 EP

1W8897 COVER GP-CYLINDER BLOCK

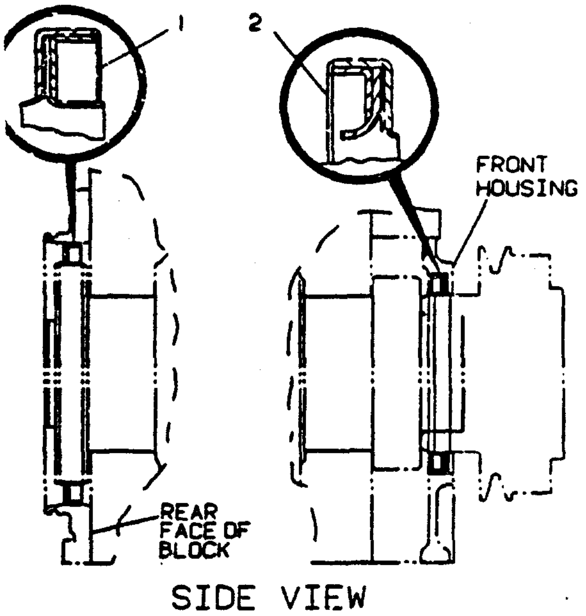
BASIC ENGINE



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	4W3989	1	CRANKSHAFT AS					
	2	1B8705	1	KEY-WOODRUFF	AF		7C7980		SLEEVE (OIL SEAL)
	3	2W8147	1	GEAR (50 TEETH)					
	4	7W9416	1	BEARING-THRUST					
A		7C6969		BEARING-THRUST 0.5MM OS					
A		7C6970		BEARING-THRUST					
				0.5MM US - 0.3MM OS					
A		7C6966		BEARING-THRUST 0.25MM US					
A		7C6967		BEARING-THRUST 0.5MM US					
	5	7W9417	3	BEARING-MAIN					
A		7C6974		BEARING-MAIN 0.5MM OS					
A		7C6975		BEARING-MAIN					
				0.5MM US-0.5MM OS					
A		7C6971		BEARING-MAIN 0.25MM US					
A		7C6972		BEARING-MAIN 0.5MM US					
	6	7W9414	1	BEARING-MAIN					
A		7C6964		BEARING-MAIN 0.5MM OS					
A		7C6965		BEARING-MAIN					
				0.5MM US-0.5MM OS					
A		7C6961		BEARING-MAIN 0.25MM US					
A		7C6962		BEARING-MAIN 0.5MM US					

A-NOT PART OF THIS GROUP
F-NOT SHOWN

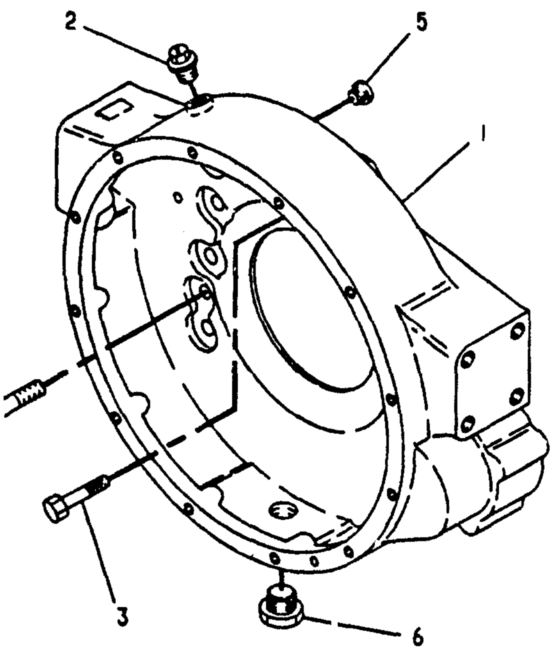
F-467199 EP



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C3570	1	SEAL GP-CRANKSHAFT
	2	7C4163	1	SEAL GP-CRANKSHAFT

C-406537 EP

4W1016 SEAL GP-CRANKSHAFT

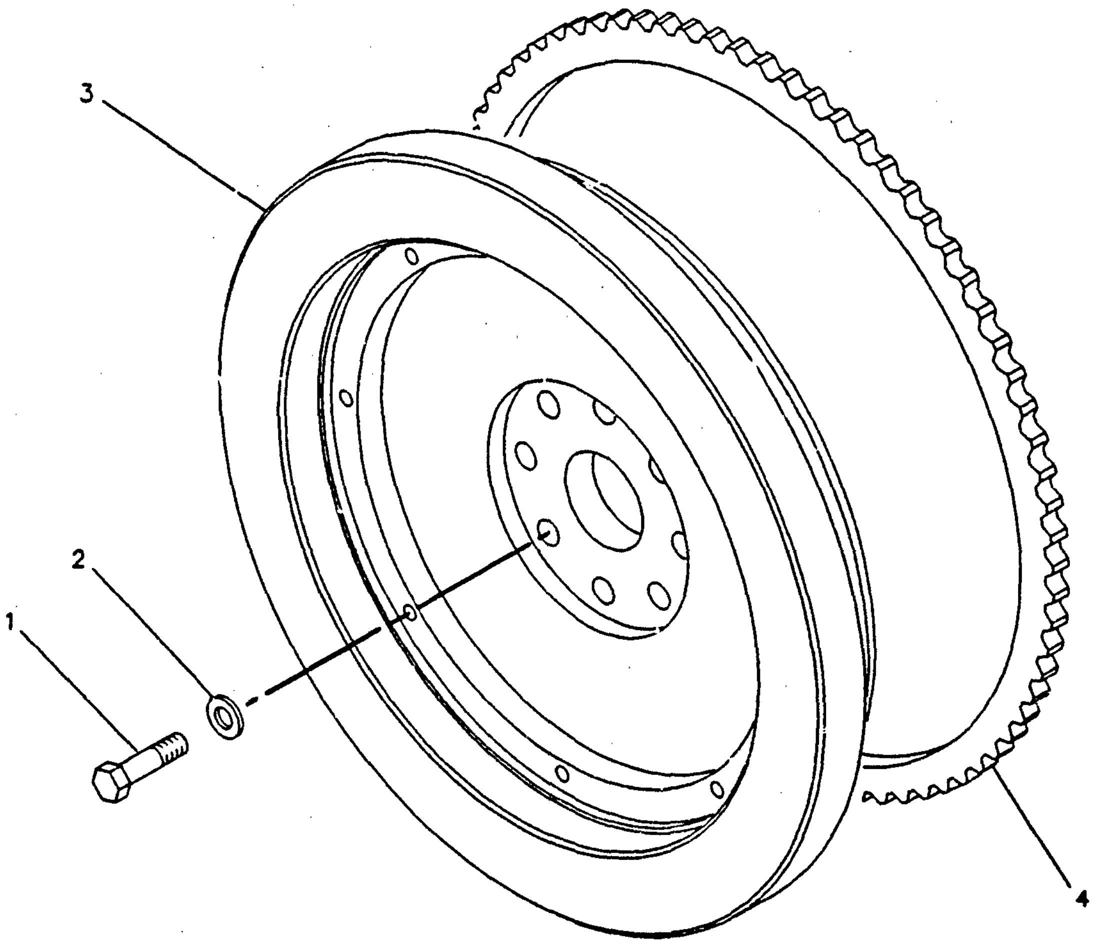


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C5233	1	HOUSING-FLYWHEEL
	2	2P1294	1	PLUG-SEALING
M	3	6V5842	2	BOLT
M	4	7X3347	10	BOLT-LOCKING
	5	9S4182	1	PLUG
CB	6	9S4183	1	PLUG

B-USE AS REQUIRED
C-CHANGE FROM PREVIOUS TYPE
M-METRIC PART

A-476491 EP

7W8813 HOUSING GP-FLYWHEEL



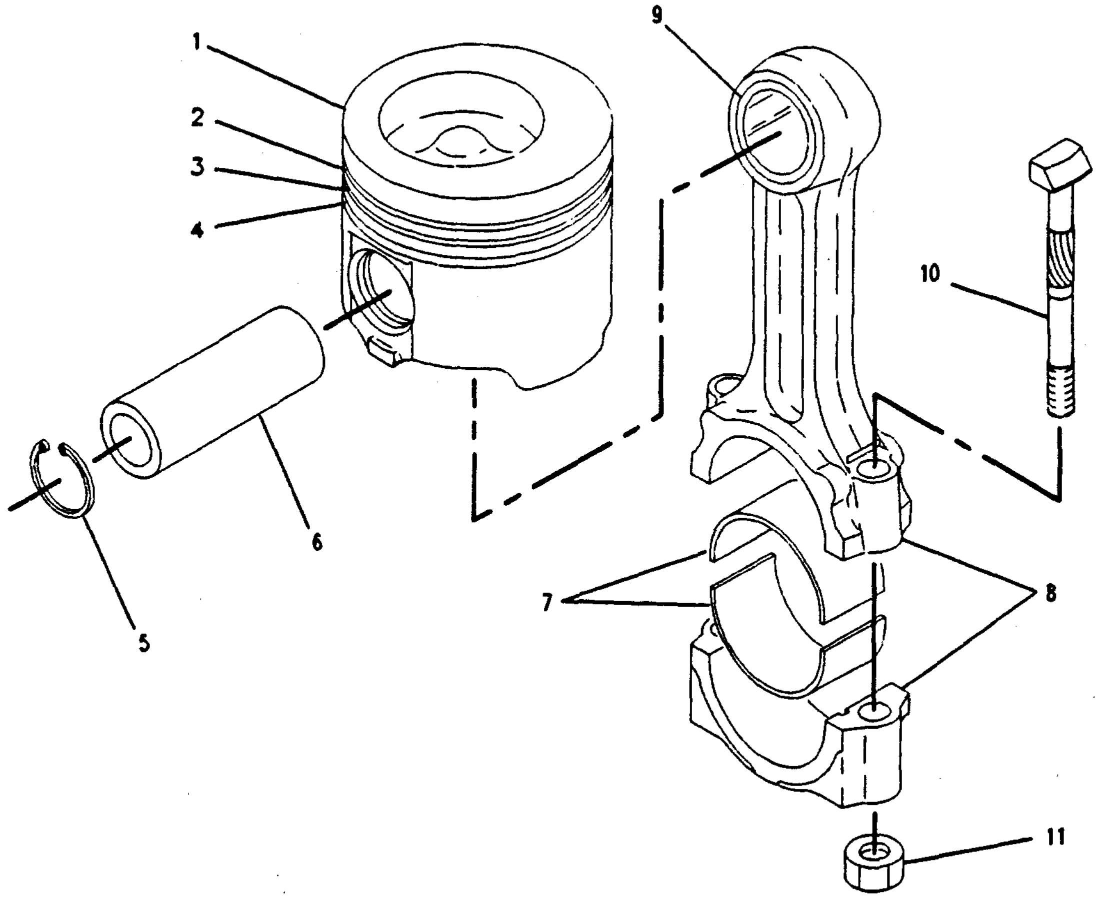
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	7X3344	8	BOLT					
	2	5P8245	8	WASHER					
	3	9Y1583	1	FLYWHEEL AS					
	4	1W1064	1	GEAR-FLY RING					

M-METRIC PART

F-498119 EP

9Y1584 FLYWHEEL GP

BASIC ENGINE



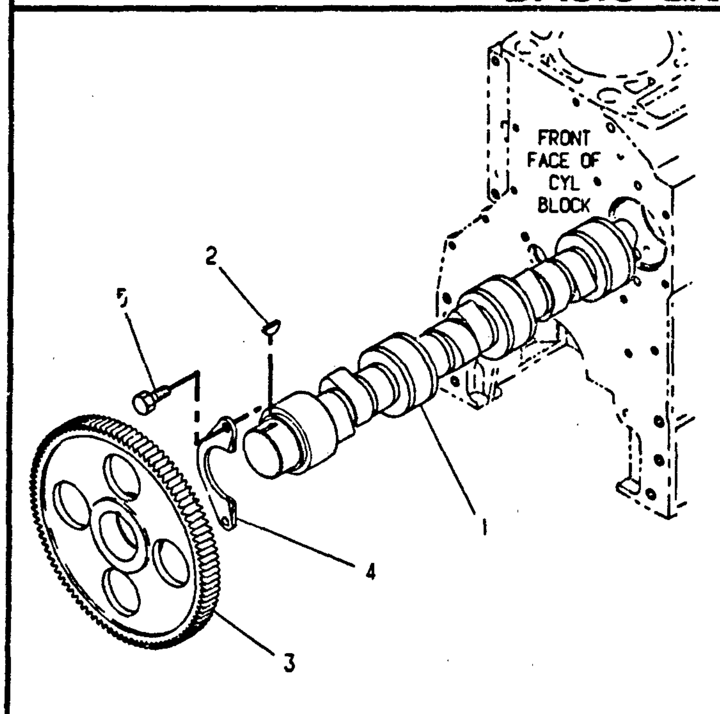
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7E3428	1	BODY AS-PISTON					
	2	7C0260	1	RING-PISTON (TOP)					
	3	7E5786	1	RING-PISTON (INTERMEDIATE)					
	4	7C5232	1	RING-PISTON (OIL)					
	5	7C0111	2	RETAINER-PIN					
	6	7C0115	1	PIN-PISTON					
	7	7W9415	1	BEARING-CONNECTING ROD					
A		7C6976	1	BEARING (.25MM US)					
A		7C6977	1	BEARING (.5MM US)					
R	8	2W9128	1	ROD AS-CONNECTING					
	9	2W0027	1	BEARING					
	10	9N3832	2	BOLT-CONNECTING ROD					
	11	9L7669	2	NUT-CONNECTING ROD					

A-NOT PART OF THIS GROUP
R-REMFG PART MAY BE AVAILABLE

F-497314 EP

7E3429 PISTON & ROD GP-4 REQUIRED

BASIC ENGINE



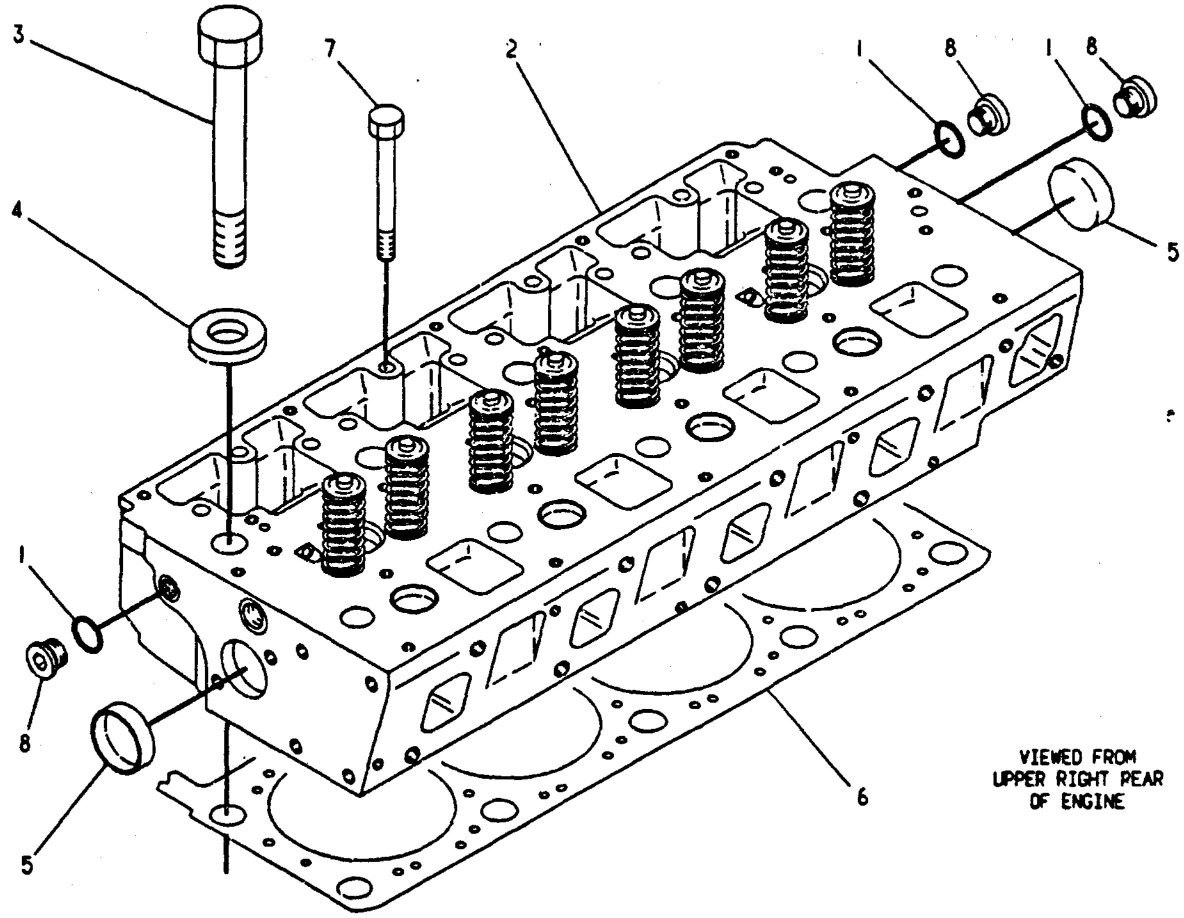
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7W2696	1	CAMSHAFT AS
	2	1B8705	1	KEY-WOODRUFF
	3	7W4070	1	GEAR (100 TEETH)
	4	7W6469	1	PLATE-THRUST
M	5	6V3940	2	BOLT

M-METRIC PART

A-457125 EP

1210 4W4865 CAMSHAFT GP-SINGLE

BASIC ENGINE



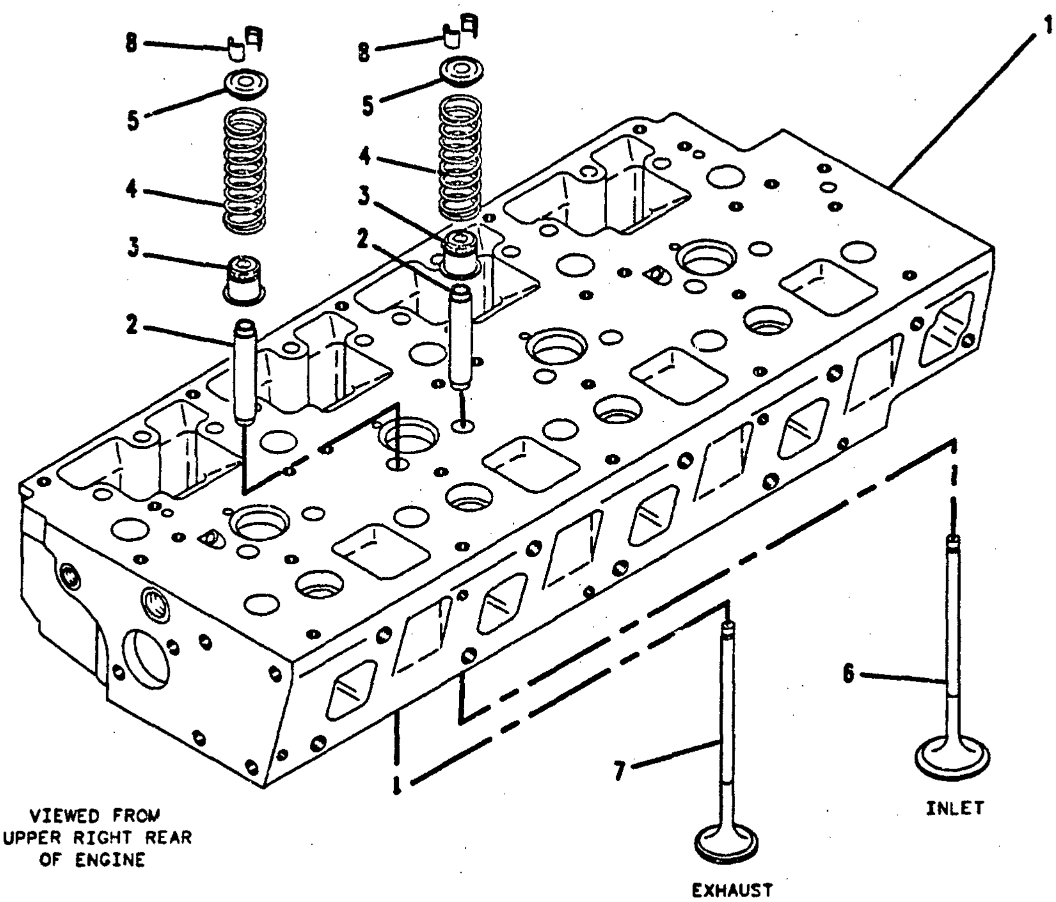
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	1J9671	3	SEAL-O-RING					
Y	2	7E4212	1	CYLINDER HEAD GP					
M	3	8T0657	10	BOLT					
	4	8T3282	10	WASHER-HARD					
	5	2M6471	2	PLUG-CUP					
	6	7W9955	1	GASKET-CYLINDER HEAD					
M	7	8T5030	4	BOLT					
	8	9S8003	3	PLUG-O-RING					

M-METRIC PART
Y-SEPARATE ILLUSTRATION

A-497318 EP

7E4211 CYLINDER HEAD GP
7E4212-Page 13

BASIC ENGINE

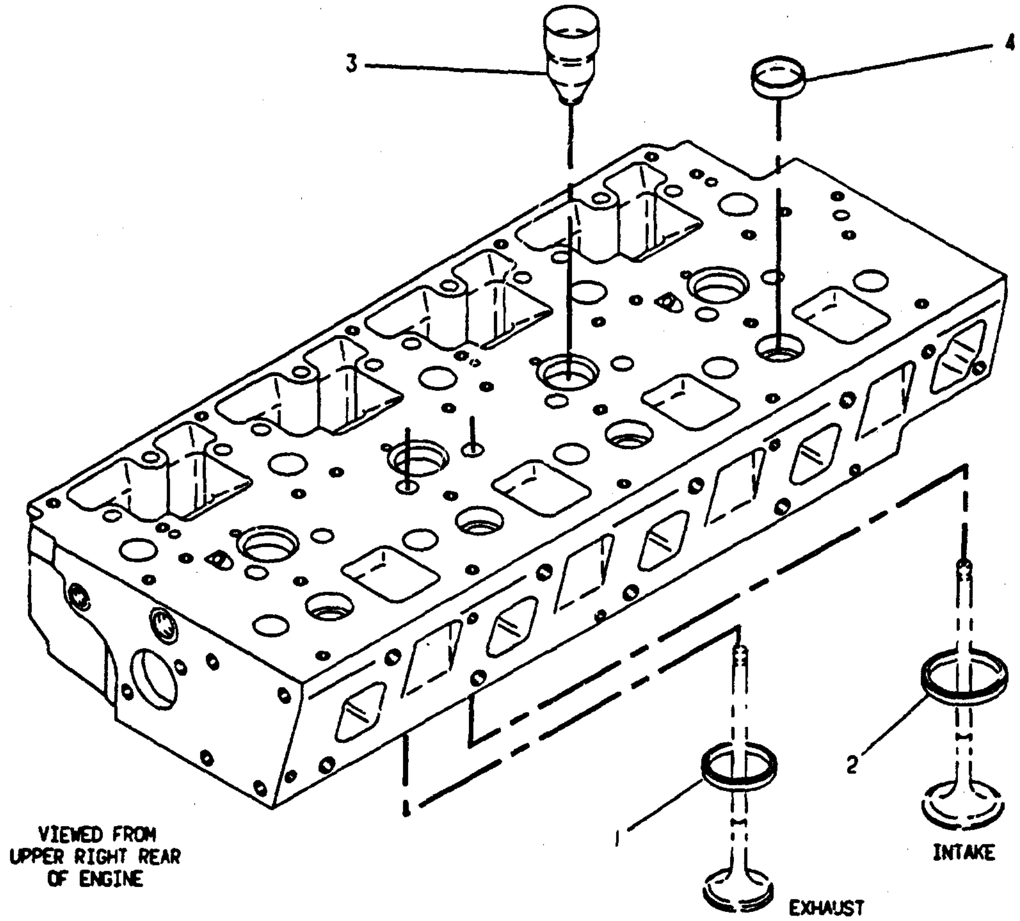


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	7E4213	1	CYLINDER HEAD AS					
	2	9Y8848	8	GUIDE-VALVE					
	3	9Y8847	8	SEAL					
	4	7C4273	8	SPRING-VALVE					
	5	7E7779	8	RETAINER-SPRING					
	6	7W8064	4	VALVE-INLET					
	7	7W2699	4	VALVE-EXHAUST					
	8	1W2715	16	LOCK-RETAINER					

Y-SEPARATE ILLUSTRATION

F-497322 EP

BASIC ENGINE

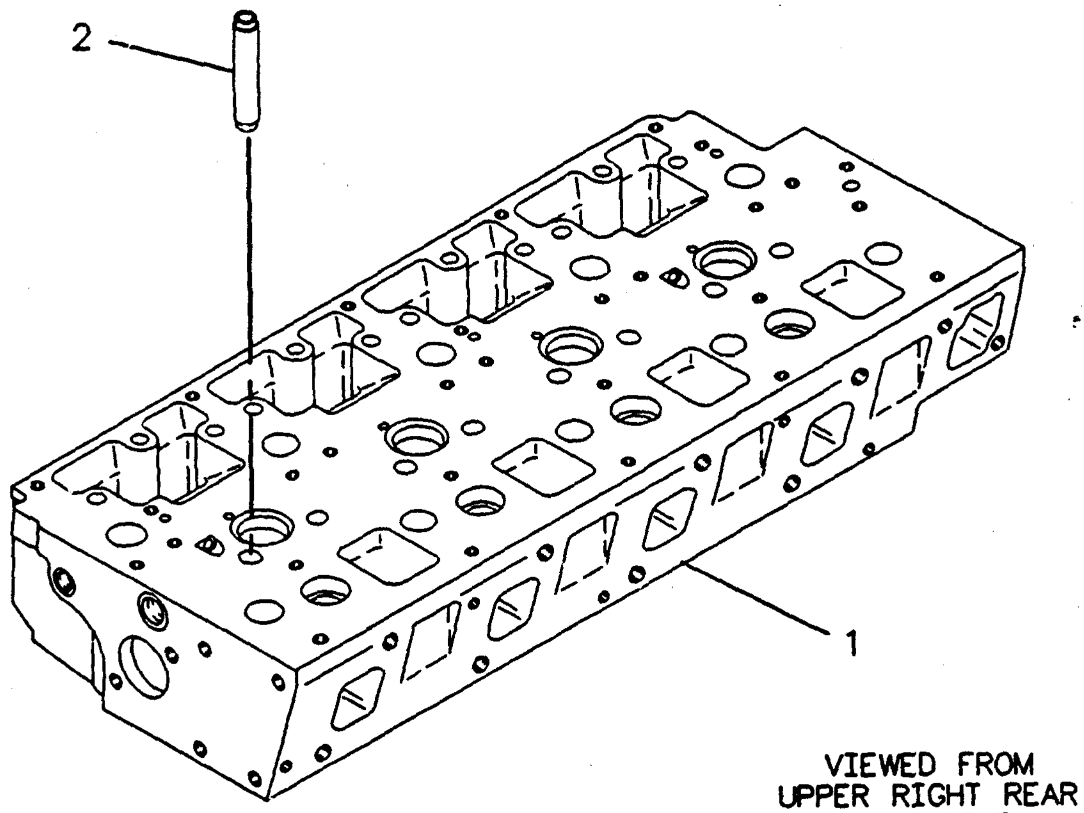


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	1W2713	4	INSERT-VALVE SEAT					
	2	7W8065	4	INSERT-SEAT					
	3	7W5749	4	SLEEVE					
	4	8M5860	4	PLUG-CUP					

A-497324 EP

7E4213 CYLINDER HEAD AS
Part Of 7E4212 Cylinder Head
For Field Replacement Order 7E4215-Page 15

BASIC ENGINE



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	7E4213	1	CYLINDER HEAD AS					
	2	9Y8848	8	GUIDE-VALVE					

Y-SEPARATE ILLUSTRATION

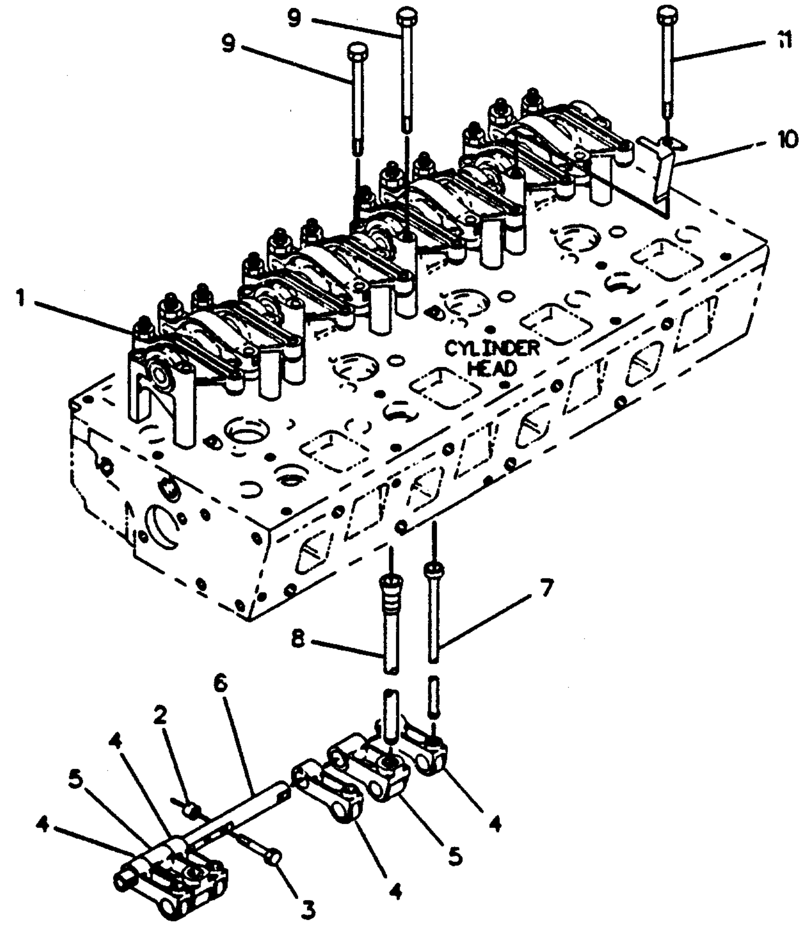
F-497327 EP

7E4215 CYLINDER HEAD AS

7E4213-Page 14

Field Replacement For 7E4213 Cylinder Head

BASIC ENGINE

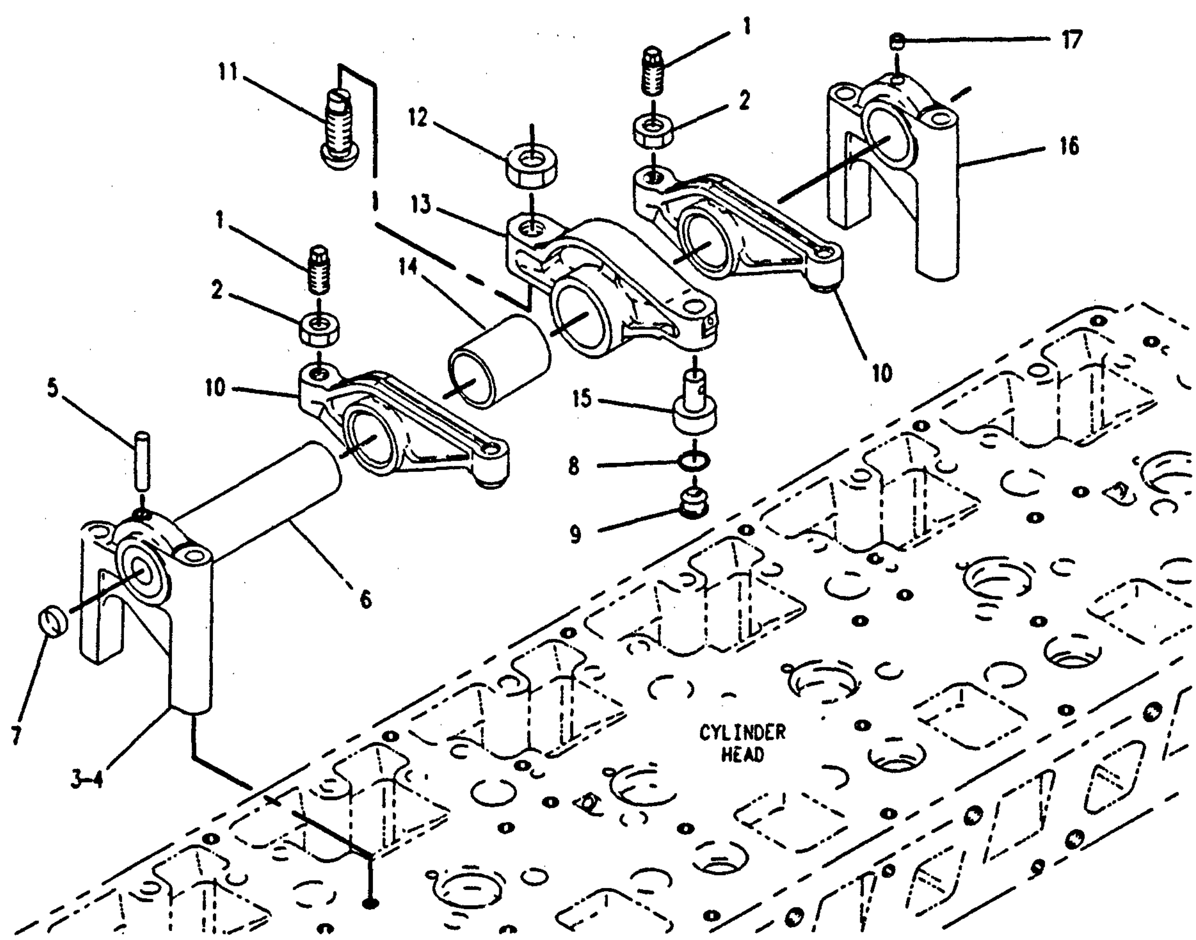


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	7C6077	4	ROCKER ARM GP-VALVE					
	2	7W4069	4	SLEEVE					
M	3	8T8442	8	BOLT-SOCKET HEAD					
	4	7W3989	8	ARM AS-LIFTER					
	5	7E4072	4	ARM AS-LIFTER					
	6	7W4339	2	SHAFT AS-LIFTER (EACH INCLUDES)					
		3S6605	2	PLUG-CUP					
	7	7E4199	8	ROD-VALVE PUSH					
	8	7E7309	4	ROD AS-INJECTOR PUSH					
M	9	6V5223	15	BOLT					
	10	7E5984	1	COVER-POWERSCREW					
M	11	9X6005	1	BOLT-LOCKING					

M-METRIC PART
Y-SEPARATE ILLUSTRATION

F-490035 EP

BASIC ENGINE



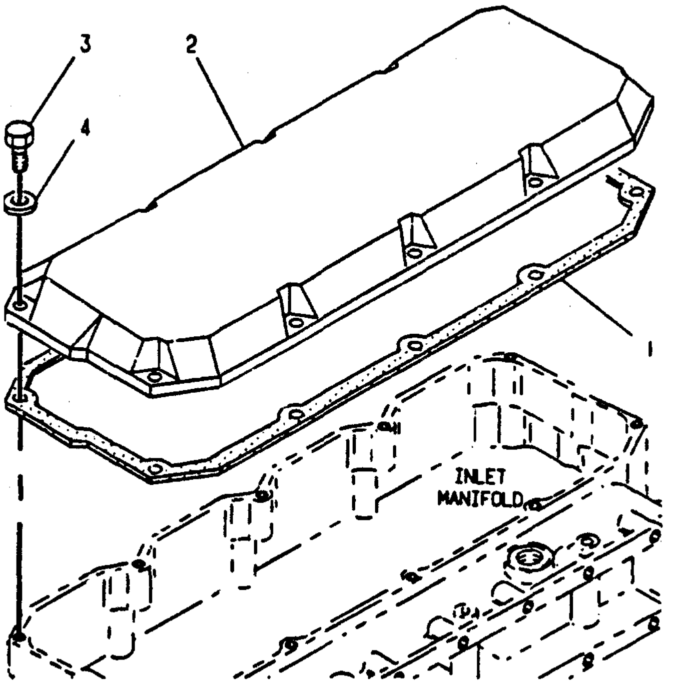
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	9Y4832	2	SCREW-VALVE ADJUSTING					
M	2	2Y5829	2	NUT					
	3	9Y8532	1	SHAFT AS-ARM					
	4	9Y8533	1	SUPPORT-SHAFT					
	5	7M5130	1	PIN					
	6	7W4137	1	SHAFT AS					
	7	0L1026	1	PLUG-CUP					
	8	7W3983	1	RING-RETAINER					
	9	9Y1582	1	BUTTON-ARM					
	10	7W4338	2	ARM AS-ROCKER					
	11	9Y4073	1	SCREW-INJECTION ADJUST					
M	12	7W4117	1	NUT					
	13	9Y3222	1	ARM AS-UNIT INJ					
Z	14		1	BEARING-SLEEVE					
Z	15		1	SOCKET-ARM					
	16	7E7922	1	SUPPORT AS-SHAFT					
		9Y8533	1	SUPPORT-SHAFT					
	17	8S0527	1	PLUG-CUP					

M-METRIC PART
Z-NOT SERVICED SEPARATELY

F-496549 EP

7C6077 ROCKER ARM GP-VALVE-4 REQUIRED
Part Of 4W4866 Mechanism-Fuel Pump & Valve

BASIC ENGINE



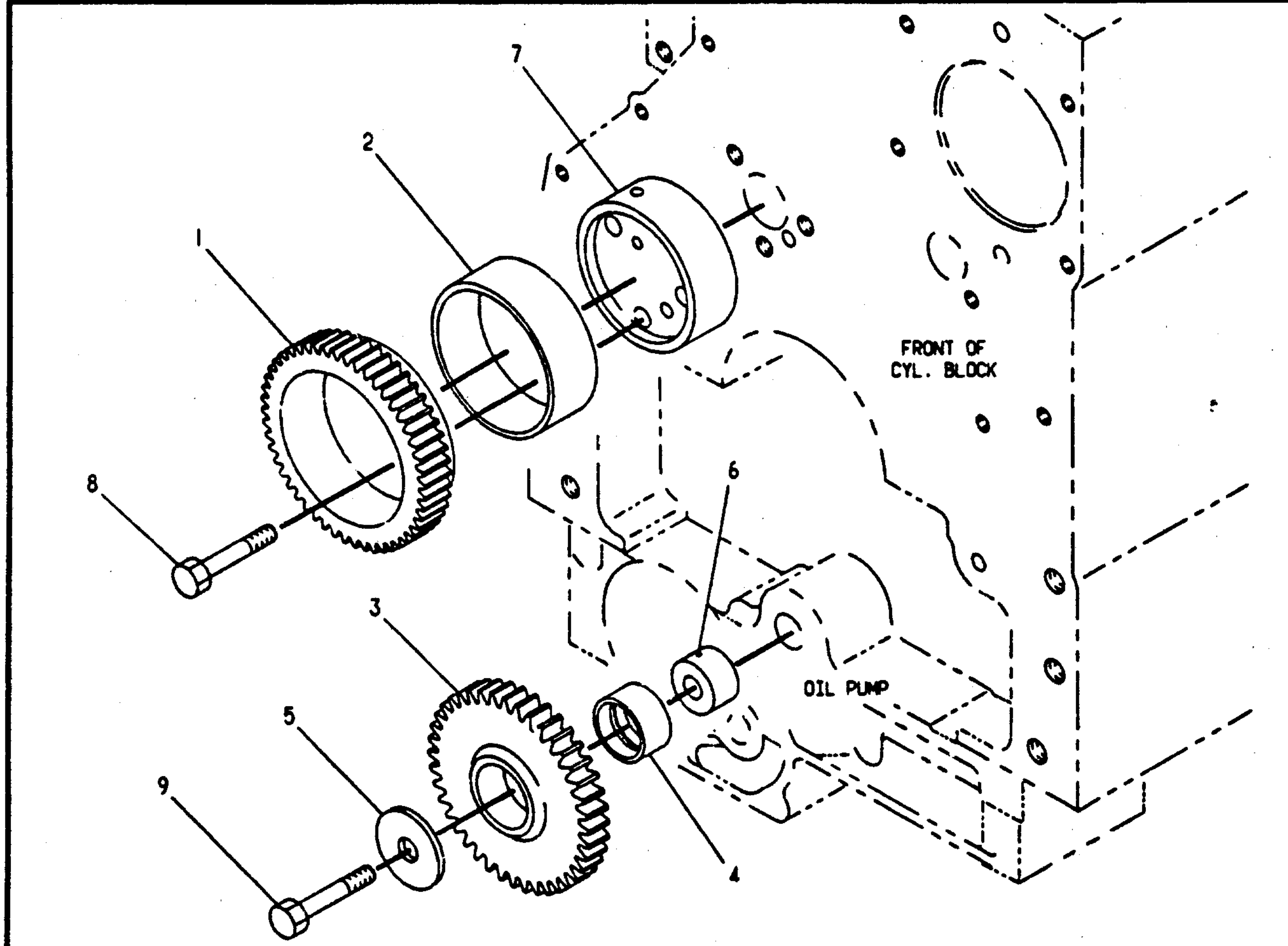
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9Y8104	1	GASKET
	2	7W7338	1	COVER
M	3	6V8490	10	BOLT
	4	5P0537	10	WASHER

M-METRIC PART

A-464563 EP

)7 7W7337 COVER GP-VALVE MECHANISM

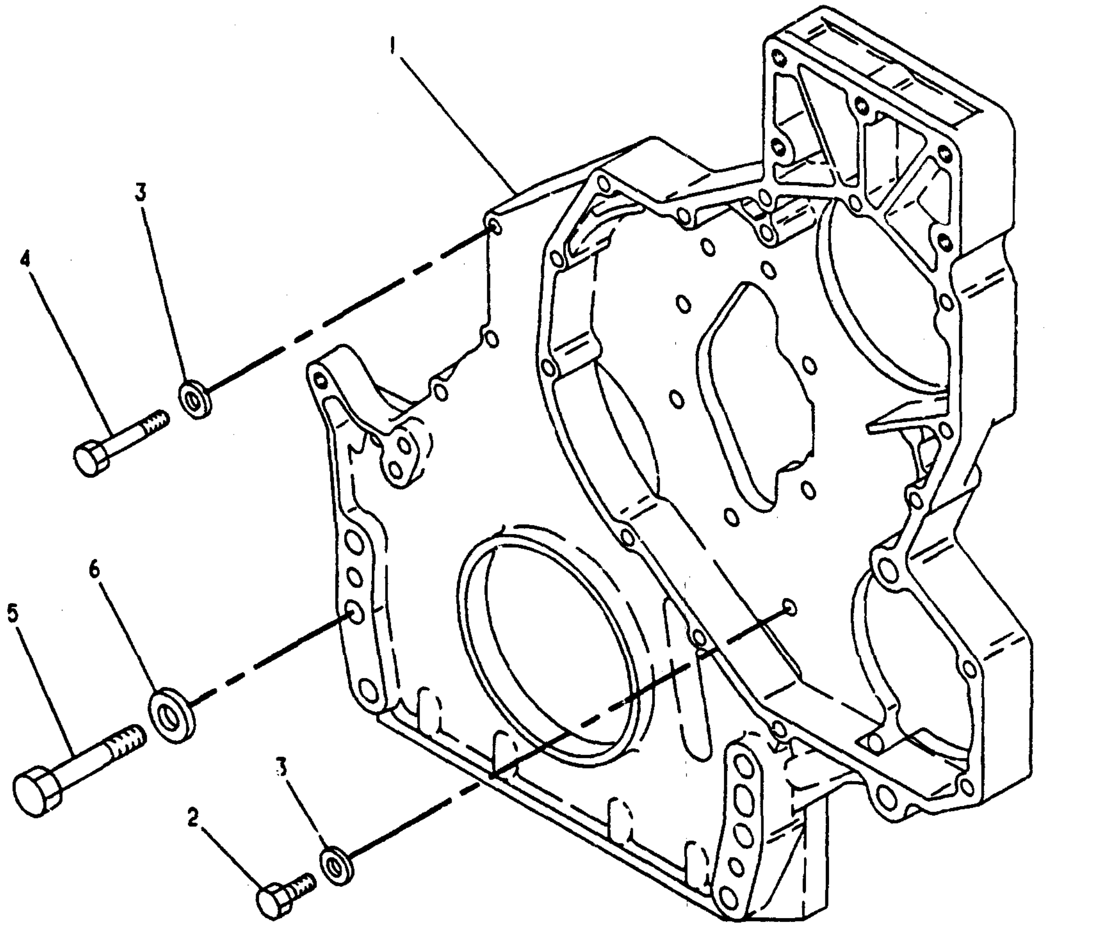
BASIC ENGINE



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2W8476	1	GEAR AS-IDLER (50 TEETH)
	2	2W7566	1	BEARING-SLEEVE
	3	7E3755	1	GEAR AS-IDLER (43 TEETH)
	4	7E3346	1	BEARING-SLEEVE
	5	6V5839	1	WASHER
	6	7E3345	1	SHAFT-IDLER
	7	2W7565	1	SHAFT-IDLER
M	8	6V3822	3	BOLT
M	9	6V5842	1	BOLT

M-METRIC PART

A-498917 EP

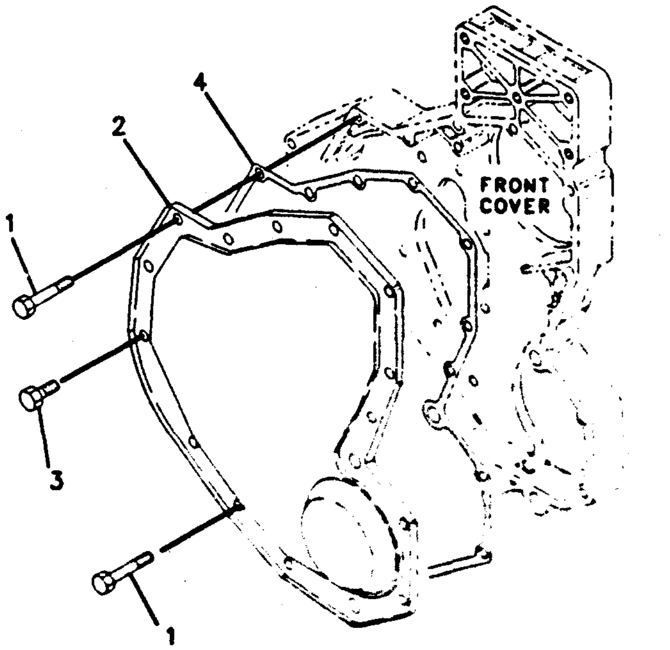


REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
1	7E6366	1	HOUSING-FRONT GEAR					
	1U8846		LIQUID GASKET					
2	6V5217	8	BOLT					
3	9M1974	12	WASHER					
4	6V3918	4	BOLT					
5	6V8336	6	BOLT					
6	5P8245	6	WASHER					

SE AS REQUIRED
HANGE FROM PREVIOUS TYPE
ETRIC PART

A-503122 EP

7L0002 HOUSING GP-FRONT

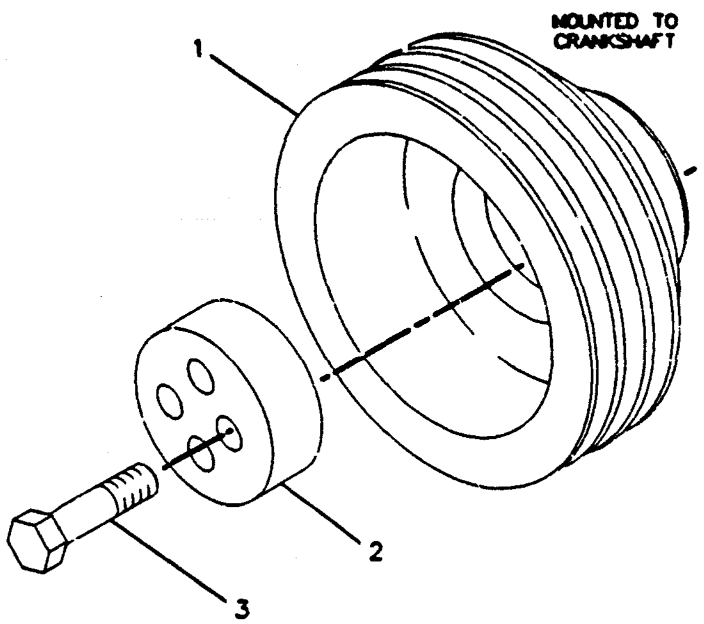


NOTE	REF NO	PART NUMBER	QTY	PART NAME
CM	1	8T0100	2	BOLT
C	2	9Y6668	1	COVER AS
CM	3	6V2317	12	BOLT
	4	7W6552	1	GASKET

C-CHANGE FROM PREVIOUS TYPE
M-METRIC PART

F-463112 EP

1151 7W3847 COVER GP-FRONT

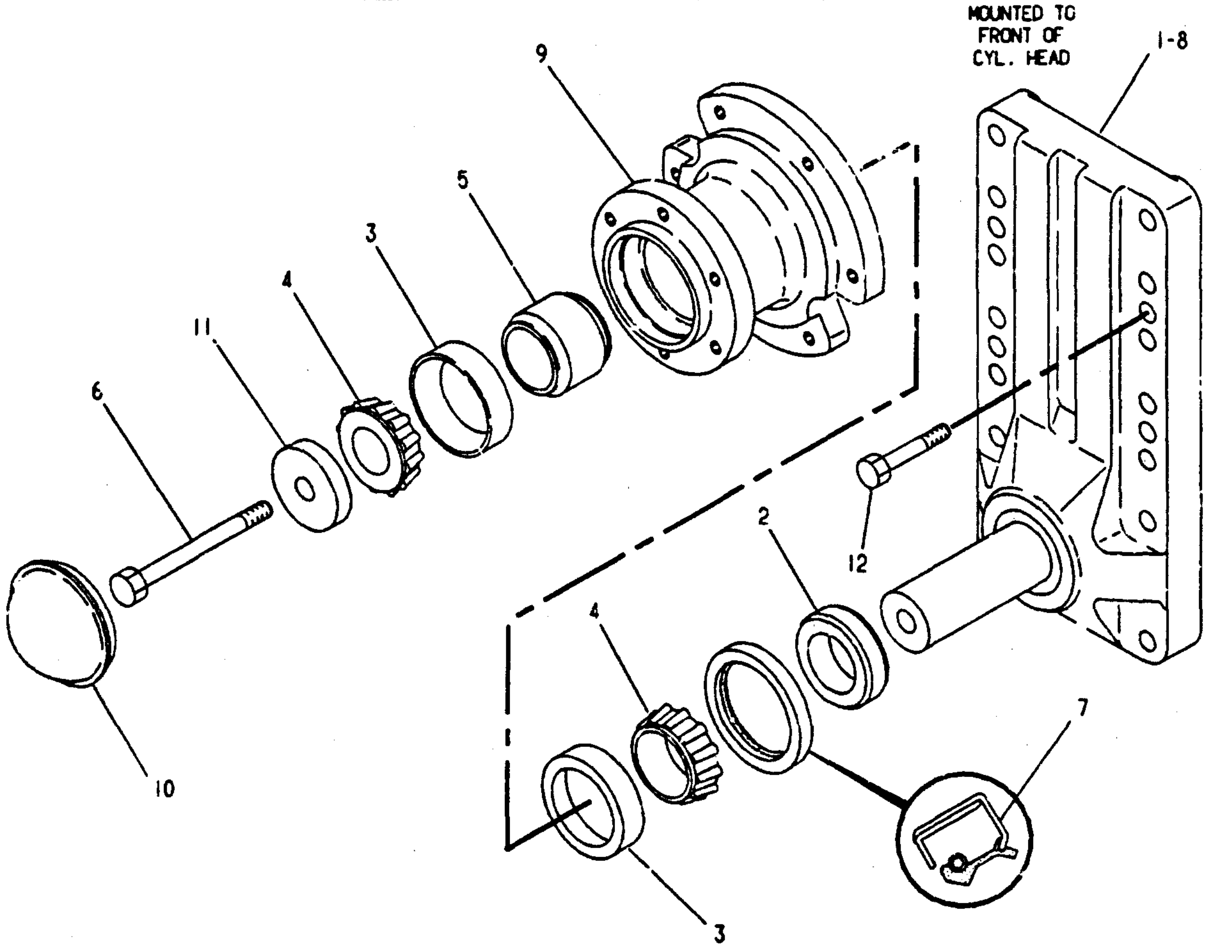


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9Y1748	1	PULLEY-CRANKSHAFT
	2	2W7381	1	WASHER-CLAMP
M	3	8T3666	4	BOLT

M-METRIC PART

F-467461 EP

1205 9Y4914 PULLEY GP-CRANKSHAFT



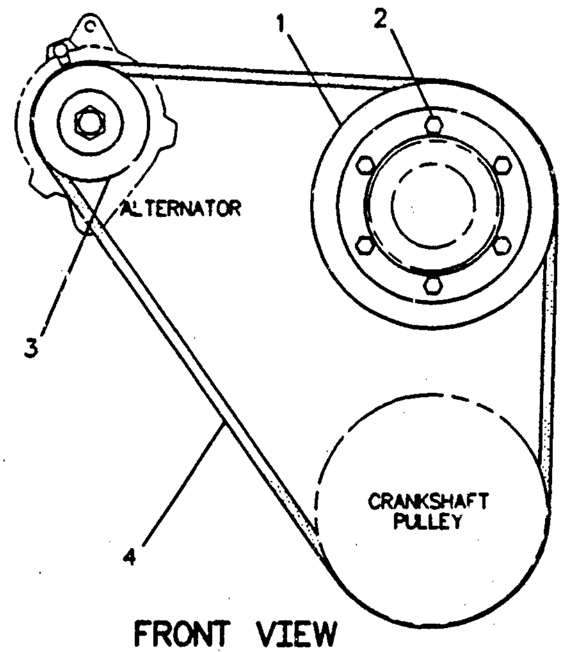
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C8365	1	DRIVE GP-FAN
	2	1W5041	1	SPACER
	3	4W1203	2	CUP-ROLLER BEARING
	4	4W1204	2	CONE-ROLLER BEARING
	5	4W2042	1	SPACER
	6	6V8004	1	BOLT
	7	6V9748	1	SEAL-LIP TYPE
	8	7C8366	1	BRACKET AS
	9	7C8369	1	HUB
	10	7C8370	1	CAP
	11	7C8634	1	PLATE
	12	6V4249	4	BOLT

METRIC PART

A-406108 EP

7C0044 DRIVE GP-FAN

BASIC ENGINE

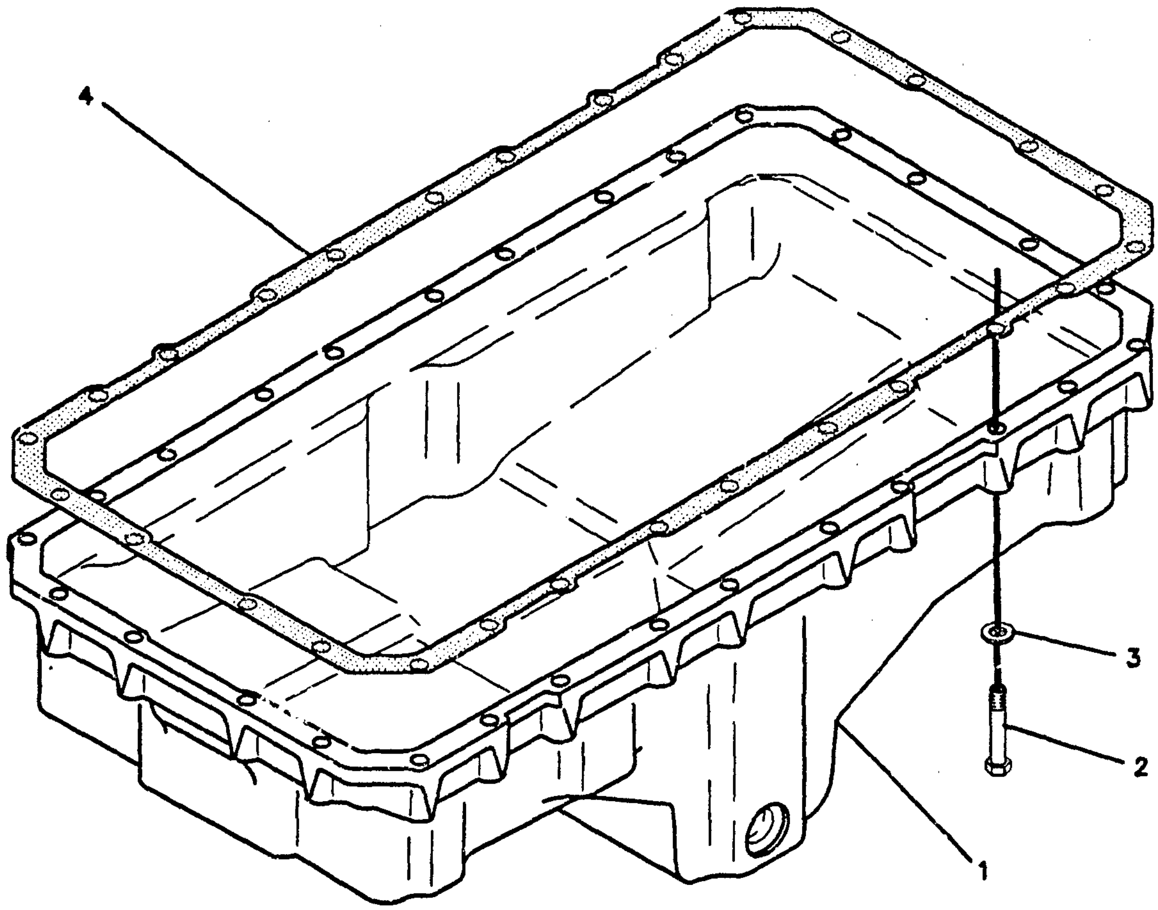


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C1390	1	PULLEY-FAN
M	2	8T4908	6	BOLT
	3	9Y4053	1	PULLEY-ALTERNATOR
	4	9L1553	1	V-BELT

M-METRIC PART

F-498

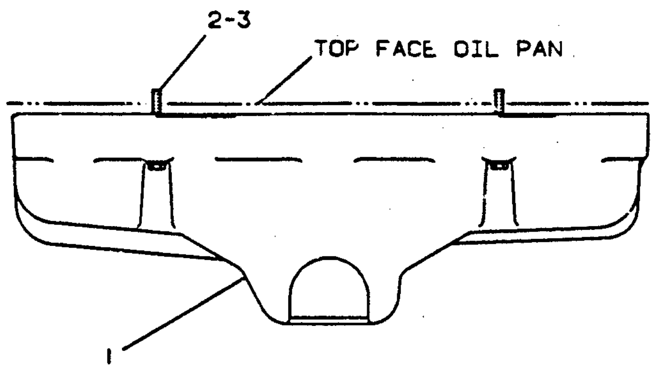
9Y7234 PULLEY GP-FAN DRIVE



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C1149	1	PAN-OIL					
M	2	6V3918	28	BOLT					
	3	9M1974	28	WASHER					
	4	7C1150	1	GASKET-OIL PAN					

M-METRIC PART

F-462304 EP

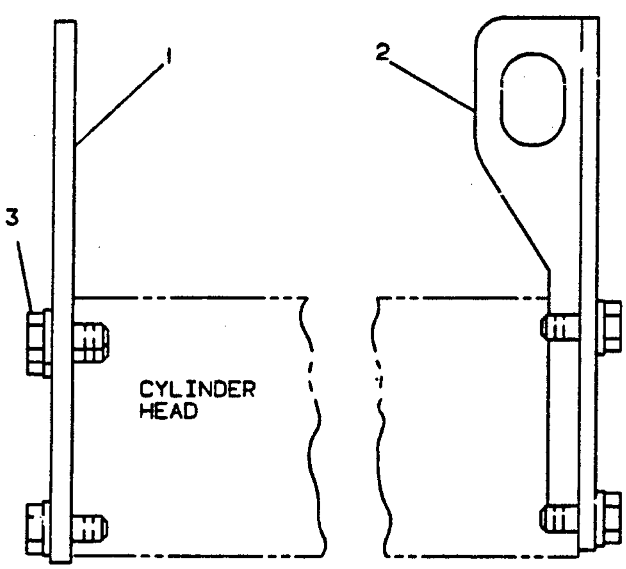


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9Y8049	1	COVER AS
M	2	8T6870	4	BOLT
	3	8T4224	4	WASHER

M-METRIC PART

C-4674

7261 9Y8048 COVER GP-OIL PAN

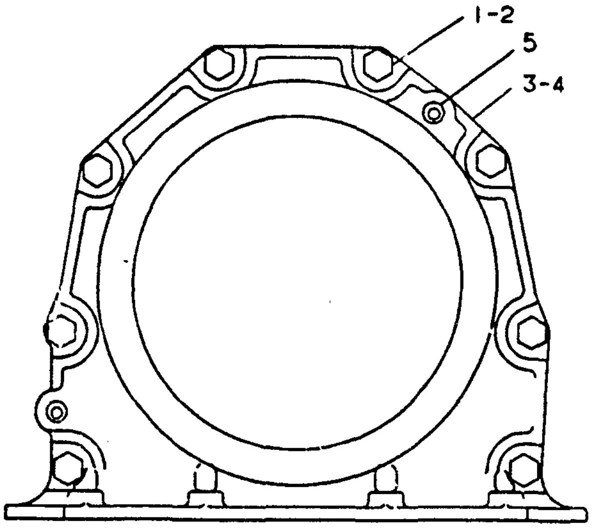


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	4W1682	1	PLATE-LIFTING
	2	4W1683	1	PLATE-LIFTING
M	3	6V4248	8	BOLT
		6V5839	8	WASHER

M-METRIC PART

C-40860

1122 4W2515 LIFTING GP



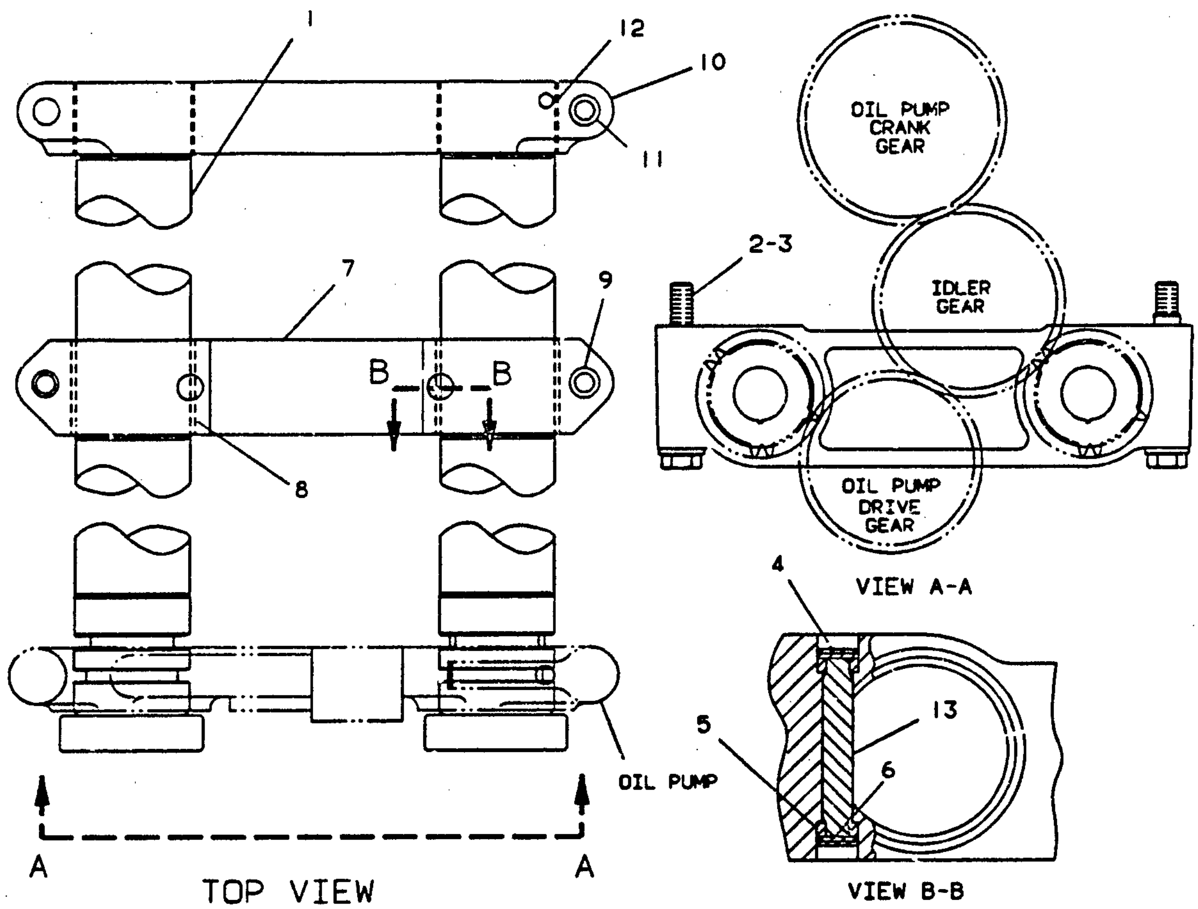
MOUNTED ON REAR OF CYLINDER BLOCK

NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V3940	8	BOLT
	2	9M1974	8	WASHER
	3	2W6546	1	COVER
B	4	6V6640		SEALANT
	5	6V3538	2	DOWEL

B-USE AS REQUIRED
M-METRIC PART

R-497378 EP

1201 4W3462 CARRIER GP-SEAL

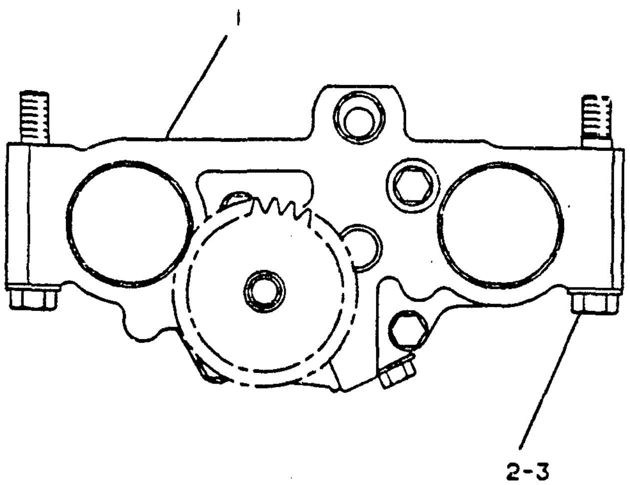


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7W9941	2	SHAFT AS-BALANCE (EACH INCLUDES)
		3B2098	1	KEY-WOODRUFF
		4B9783	1	BALL
M	2	8T0643	4	BOLT
	3	6V5839	4	WASHER
	4	3D3358	4	RING-RETAINING
	5	7E3409	4	ISOLATOR
	6	9Y9918	4	PLATE
	7	7C7199	1	SUPPORT AS-SHAFT
	8	7C7197	2	BEARING-SLEEVE
	9	7C7225	1	SLEEVE
	10	7E3757	1	SUPPORT AS-SHAFT
	11	7C7225	1	SLEEVE
	12	7E2844	2	BEARING
	13	7E2365	2	PIN-THRUST

M-METRIC PART

C-470928

LUBRICATION SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	7E3687	1	PUMP GP-ENGINE OIL
M	2	8T0643	2	BOLT
	3	6V5839	2	WASHER

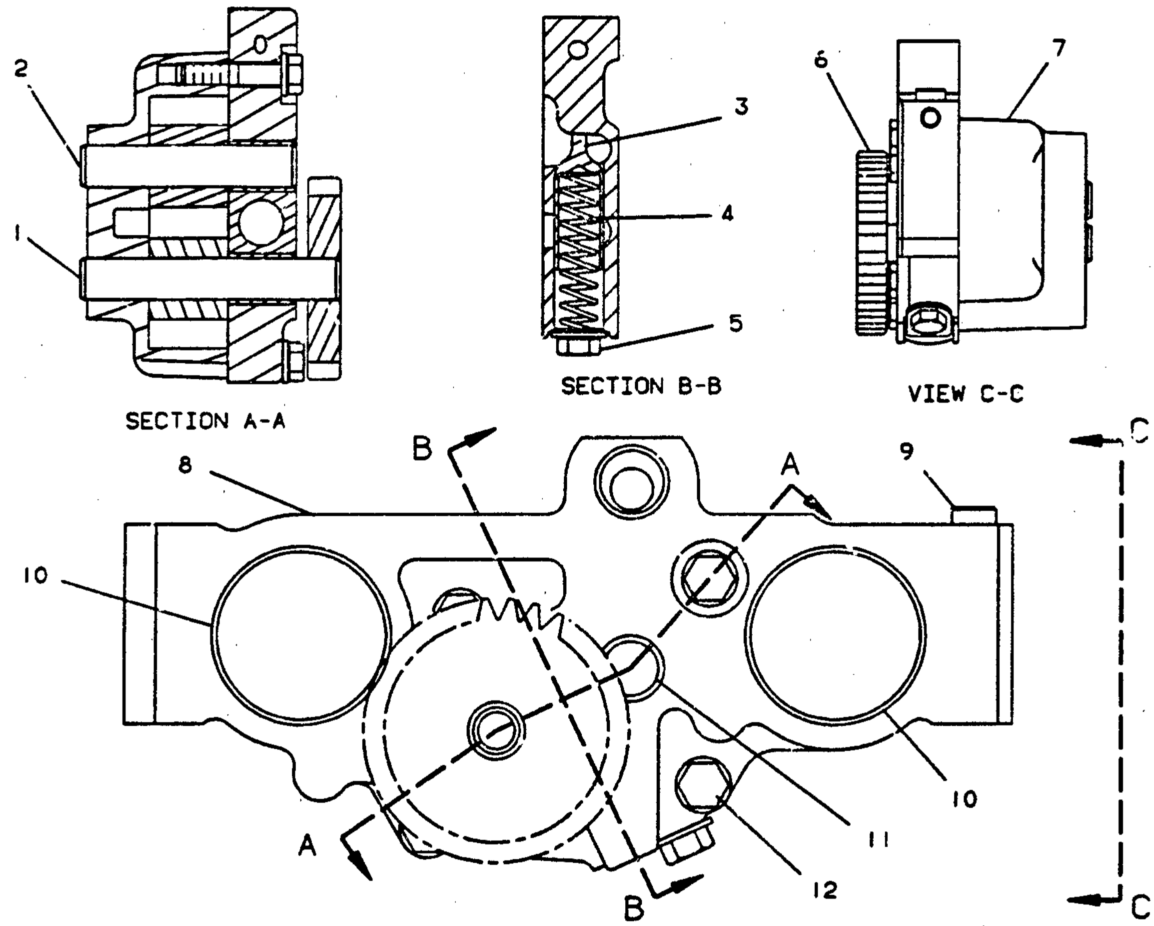
M-METRIC PART
Y-SEPARATE ILLUSTRATION

C-470913 EP

1304

7E2971 PUMP GP-ENGINE OIL
One Section Gear
7E3687-Page 29

LUBRICATION SYSTEM



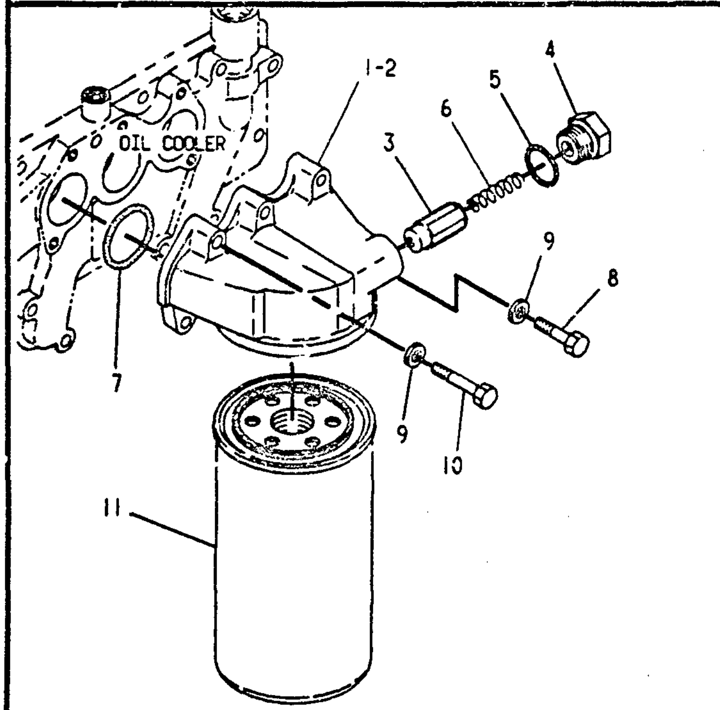
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2W8087	1	SHAFT AS
	2	2W8090	1	SHAFT AS-IDLER
	3	2W8078	1	PLUNGER-RELIEF
	4	2W8093	1	SPRING
M	5	6V5215	1	BOLT
		2W8079	1	WASHER
	6	2W8085	1	GEAR-DRIVE PUMP (33 TEETH)
	7	4W4953	1	BODY-OIL PUMP
	8	7E3688	1	BODY AS-OIL PUMP
		7E3689	1	BODY-OIL PUMP
	9	7C7225	1	SLEEVE
	10	7E2844	2	BEARING
	11	7E4611	2	BUSHING
M	12	6V5219	4	BOLT
		9M1974	4	WASHER

M-METRIC PART

C-470914

7E3687 PUMP GP-ENGINE OIL
One Section Gear
Part Of 7E2971 Pump-Engine Oil

LUBRICATION SYSTEM

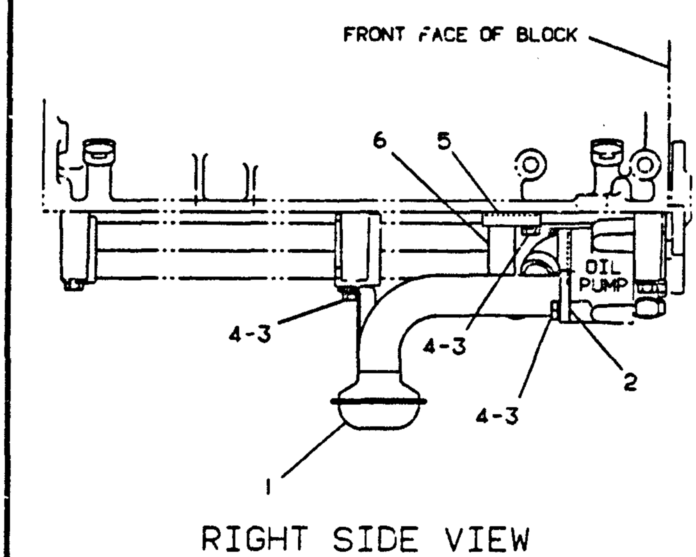


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7W9028	1	BASE AS-OIL
	2	2P2537	1	STUD-HOLLOW
	3	7C1493	1	VALVE-BYPASS
	4	5P8196	1	PLUG-O-RING
	5	2M9780	1	SEAL-O-RING
	6	9L9188	1	SPRING-VALVE
	7	5F9657	3	SEAL-O-RING
M	8	6V2317	2	BOLT
	9	9M1974	5	WASHER
M	10	6V5219	3	BOLT
	11	1R0714	1	FILTER AS-OIL

M-METRIC PART

A-485117 EP

1306 7C0896 FILTER GP-ENGINE OIL



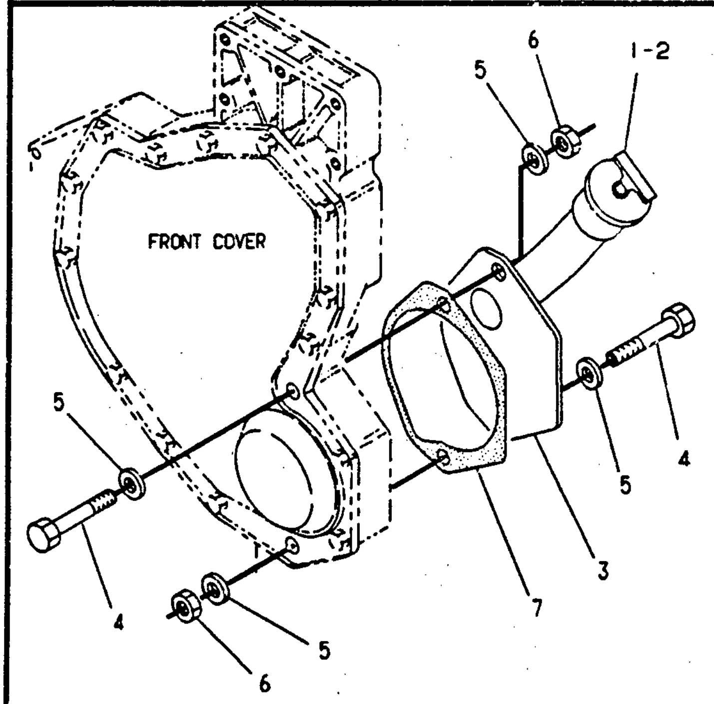
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C1629	1	TUBE AS-SUCTION
	2	7W5340	1	GASKET
M	3	6V3940	5	BOLT
	4	9M1974	5	WASHER
	5	3P1156	2	SEAL-O-RING
	6	4W8659	1	TUBE AS

M-METRIC PART

C-462096 EP

1307 7C0897 LINES GP-ENGINE OIL

LUBRICATION SYSTEM

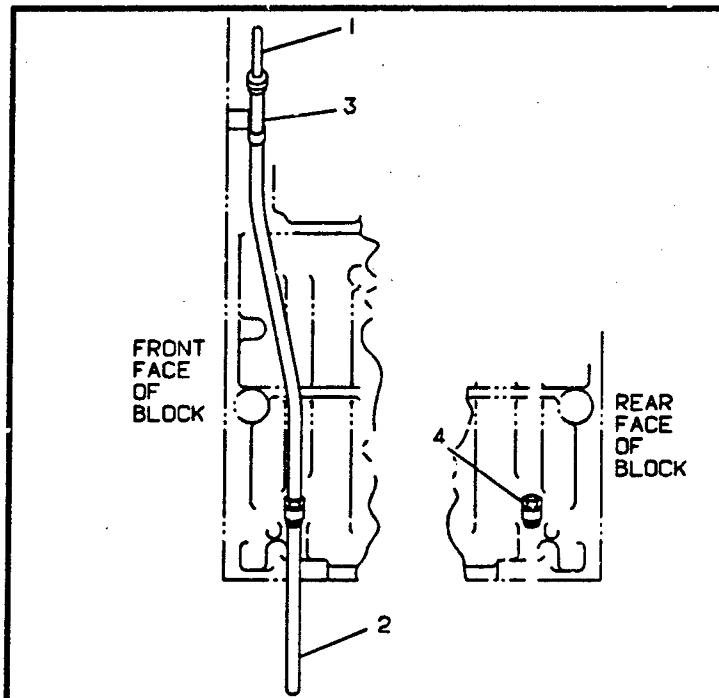


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	5L2952	1	CAP AS-OIL FILLER
	2	6L2609	1	SEAL-RUBBER
	3	7C0714	1	TUBE AS-FILLER
M	4	6V8336	2	BOLT
	5	5P8245	4	WASHER
M	6	6V8149	2	NUT
	7	9Y4634	1	GASKET-POWER TAKE OFF

M-METRIC PART

A-498919 E

1316 **7W8798 FILLER GP-OIL**



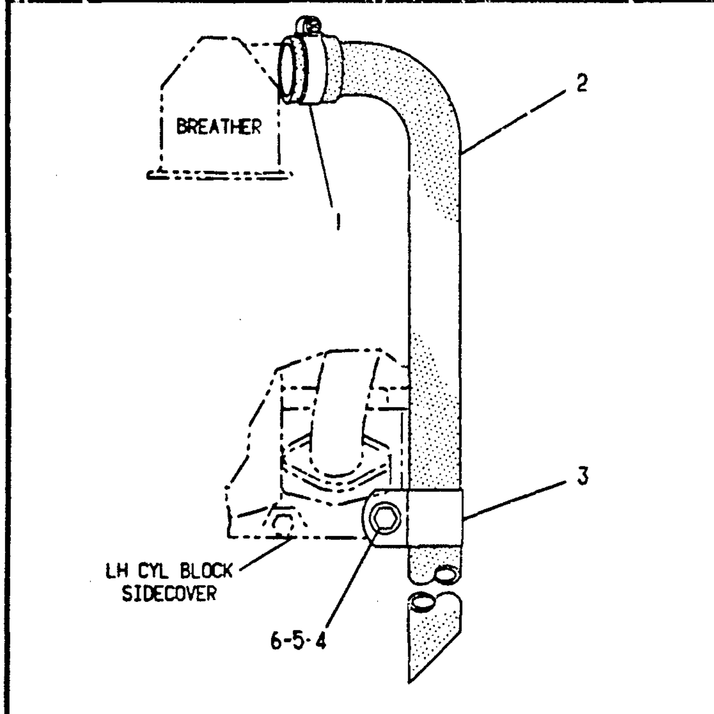
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C0707	1	GAUGE-OIL LEVEL
	2	7C0709	1	TUBE AS-GUIDE
	3	1F7567	1	CLIP
B	4	1S2563	3	PLUG

B-USE AS REQUIRED

C-476395 E

1326 **7W8796 GAUGE GP-OIL LEVEL (DIPSTICK)**

LUBRICATION SYSTEM

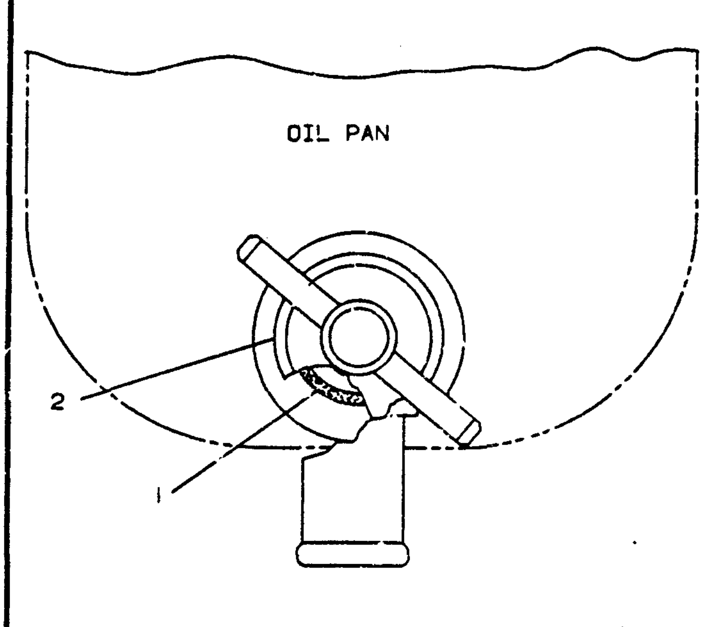


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9M2904	1	CLAMP-HOSE
	2	7C0952	1	HOSE-DISPOSAL
	3	4D7388	1	CLIP
M	4	6V3918	1	BOLT
	5	9M1974	1	WASHER
	6	392281		SPACER

M-METRIC PART

A-406547 EP

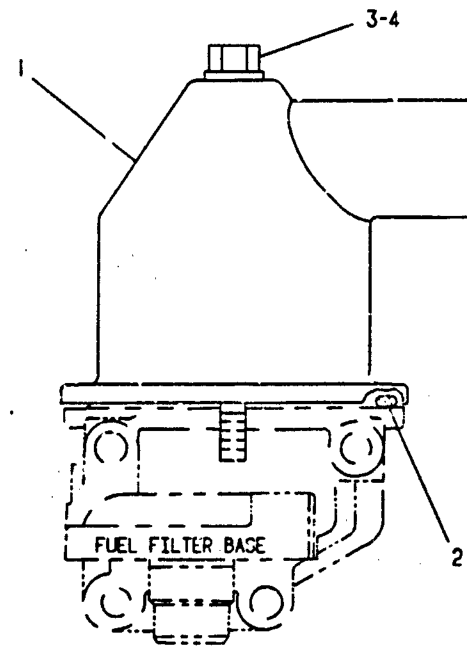
1317 7W8420 FUMES DISPOSAL GP



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	8L2786	1	SEAL-O-RING
	2	6V7238	1	VALVE-SHUT-OFF

C-408603 EP

1302 7C4532 DRAIN GP-OIL PAN

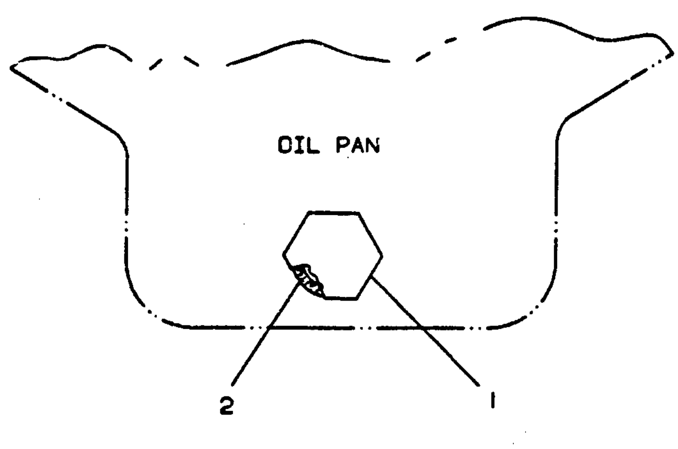


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2W9162	1	BREATHER AS
	2	4L9564	1	SEAL-O-RING
M	3	6V3821	1	BOLT
	4	9N0869	1	WASHER

M-METRIC PART

A-491289 E!

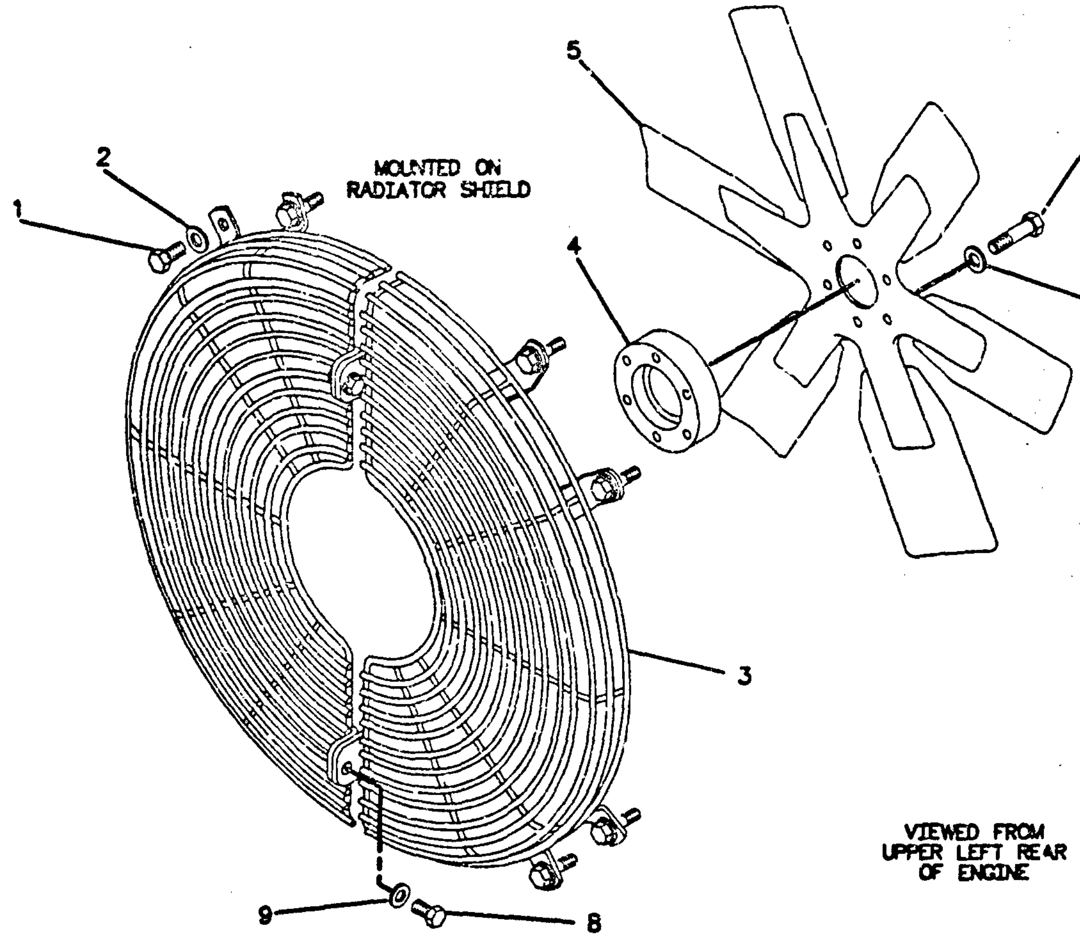
1317 **1N3477 BREATHER GP**



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9S4185	1	PLUG-O-RING
	2	8L2786	1	SEAL-O-RING

C-454380 EP

1302 **7C4566 DRAIN GP-OIL PAN**

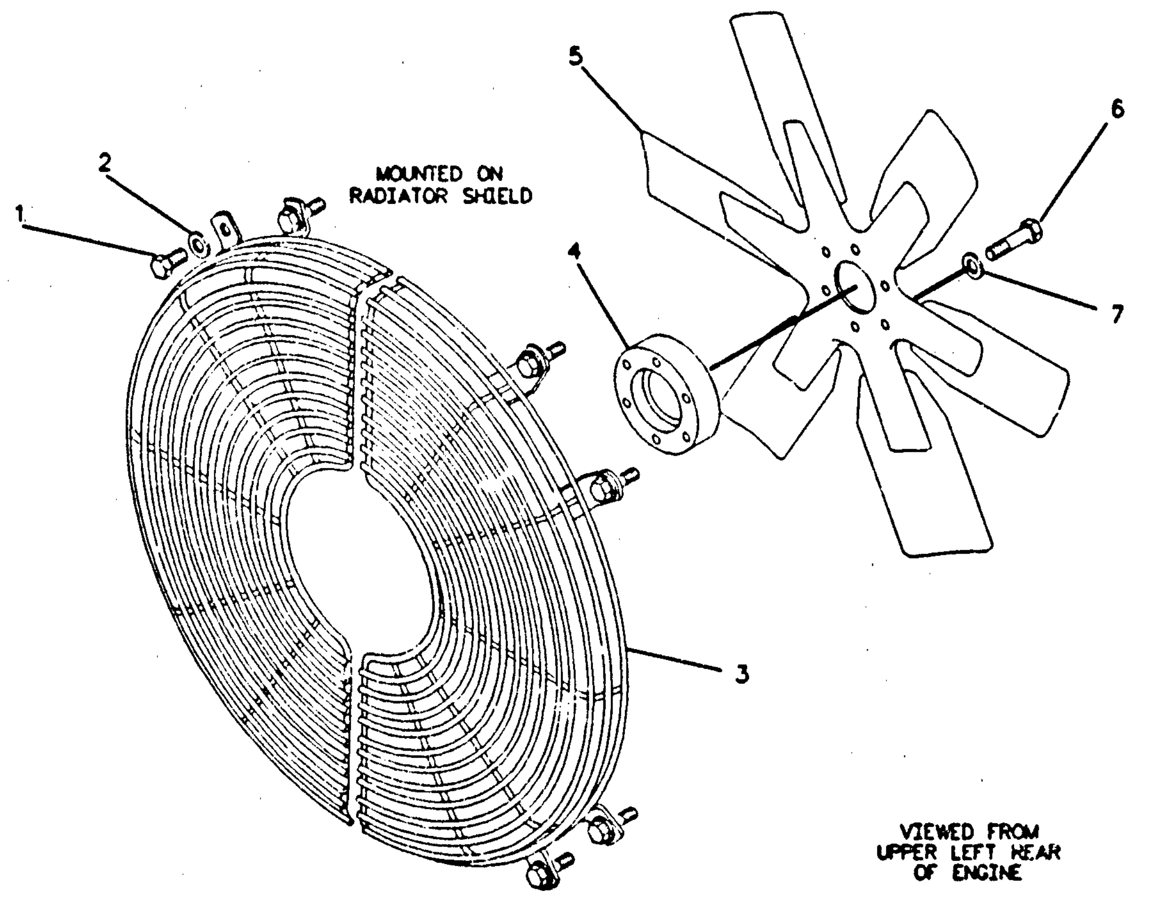


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	8T4189	8	BOLT					
	2	5P4116	8	WASHER					
	3	7W7828	2	GUARD AS-FAN					
				(EACH INCLUDES)					
		6N8599	1	CLIP					
M		8T3490	1	NUT-WELD					
	4	7C8934	1	ADAPTER-FAN					
	5	7C0876	1	SPIDER AS-FAN					
M	6	8T6869	6	BOLT					
	7	8T4224	6	WASHER					
M	8	8T4136	2	BOLT					
	9	8T4121	2	WASHER					

M-METRIC PART

F-462735 EP

COOLING SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	8T4189	8	BOLT					
	2	5P4116	8	WASHER					
	3	4P5482	2	GUARD AS-FAN					
	4	7C8934	1	ADAPTER-FAN					
	5	7C0876	1	SPIDER AS-FAN					
M	6	8T6869	6	BOLT					
	7	8T4224	6	WASHER					

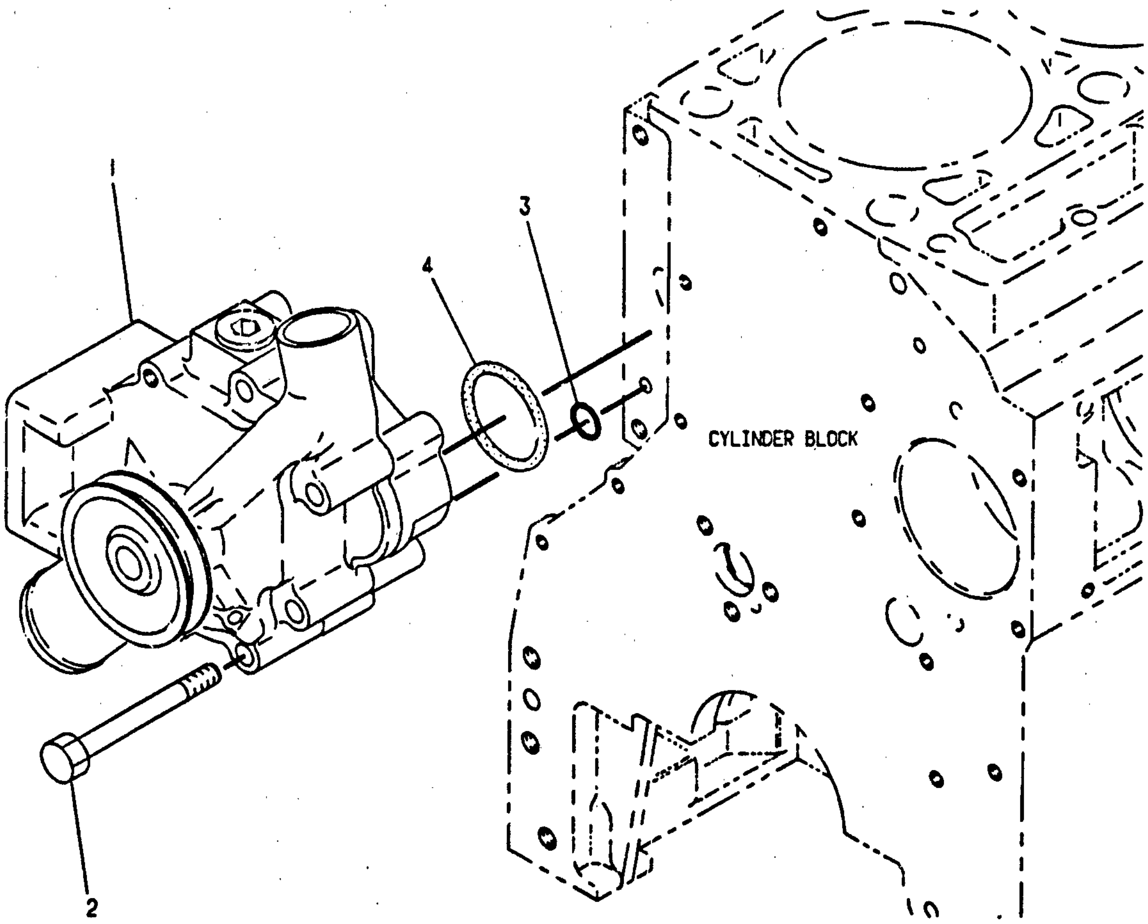
M-METRIC PART

F-512820

4P5481 FAN GP-SUCTION

MEMORANDA

COOLING SYSTEM

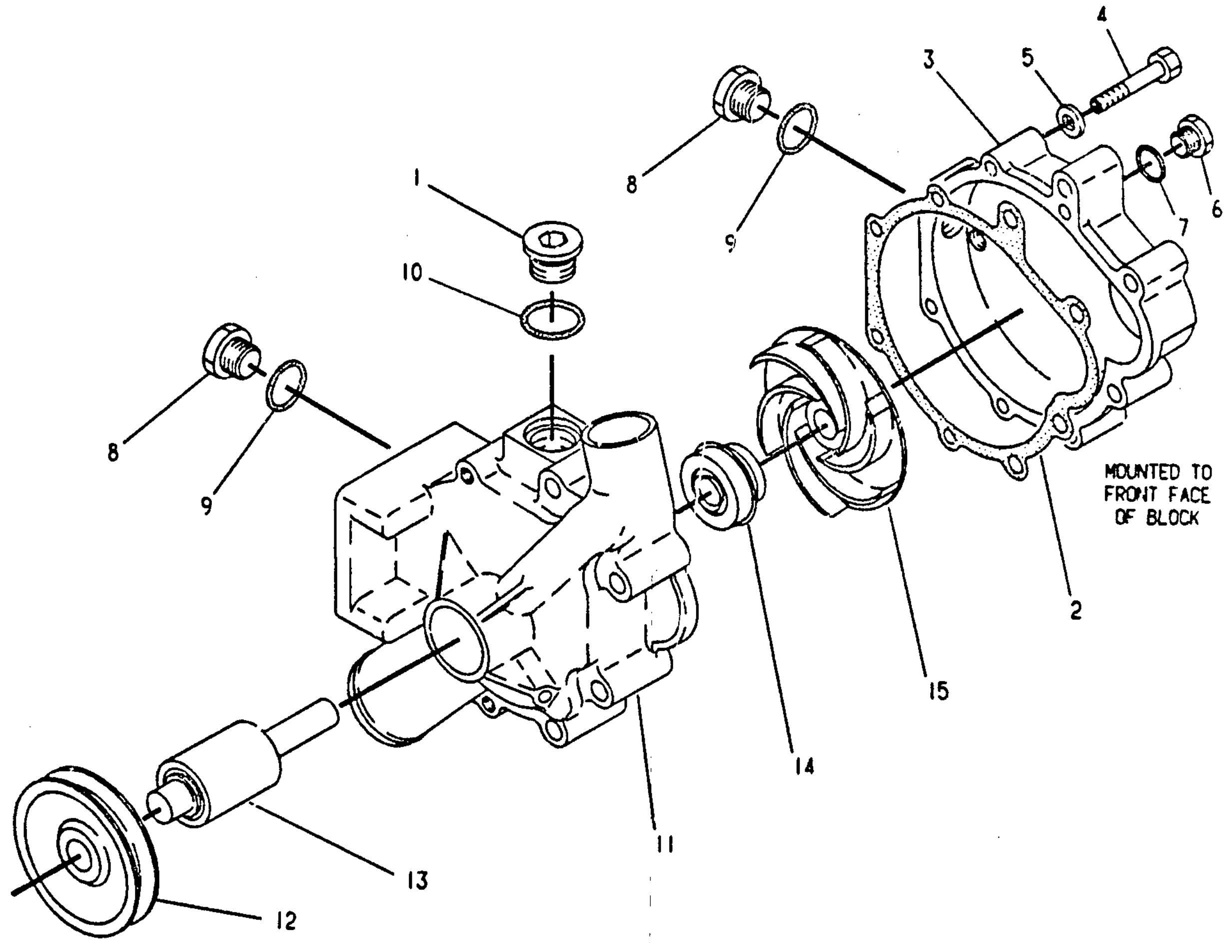


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	7C4508	1	PUMP GP-WATER					
M	2	8T0644	4	BOLT					
	3	2M4453	1	SEAL-O-RING					
	4	7F8267	1	SEAL-O-RING					

M-METRIC PART
Y-SEPARATE ILLUSTRATION

A-406132 I

COOLING SYSTEM



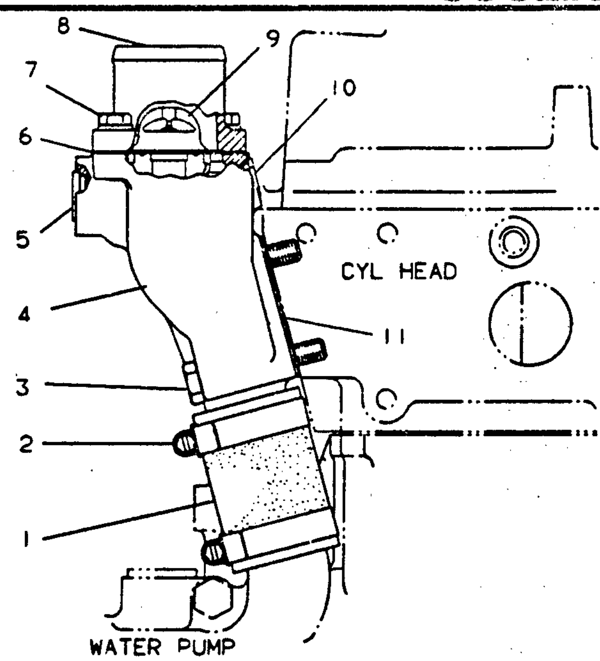
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9S8008	1	PLUG-O-RING					
	2	4W7592	1	GASKET					
	3	4W0253	1	COVER					
	4	6V3918	4	BOLT					
	5	9M1974	4	WASHER					
	6	9S8003	1	PLUG-O-RING					
	7	1J9671	1	SEAL-O-RING					
	8	9S8005	3	PLUG-O-RING					
	9	3K0360	3	SEAL-O-RING					
	10	3D2824	1	SEAL-O-RING					
	11	4W7590	1	PUMP AS-WATER					
	12	7W3780	1	PULLEY					
	13	4W0250	1	SHAFT AS					
	14	2W0712	1	SEAL AS-PUMP					
	15	4W0251	1	IMPELLER					

A-406134 EP

1361

7C4508 PUMP GP-WATER*R
Part Of 4W7589 Pump-Water

COOLING SYSTEM



FRONT VIEW

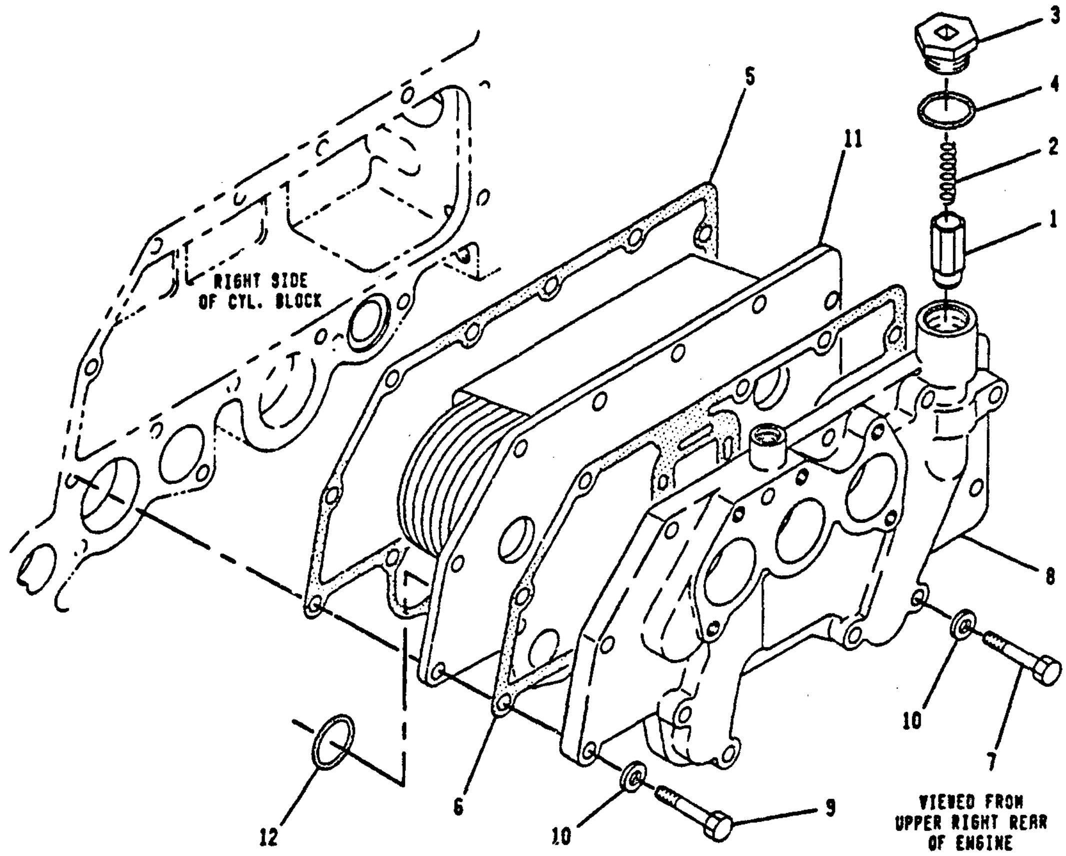
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6L3929	1	HOSE
	2	9M0164	2	CLAMP-HOSE
M	3	6V5230	2	BOLT
	4	7W1466	1	HOUSING-REGULATOR
	5	9S8005	2	PLUG-O-RING
		3K0360	2	SEAL-O-RING
	6	4W0549	1	GASKET
M	7	6V3940	2	BOLT
		9M1974	2	WASHER
	8	9Y7744	1	PIPE
	9	9Y3365	1	REGULATOR-TEMP
	10	9S8004	1	PLUG-O-RING
		3J1907	1	SEAL-O-RING
	11	2W7212	1	GASKET-REGULATOR

M-METRIC PART

C-467453 EF

1380 9Y7743 LINES GP-WATER

COOLING SYSTEM

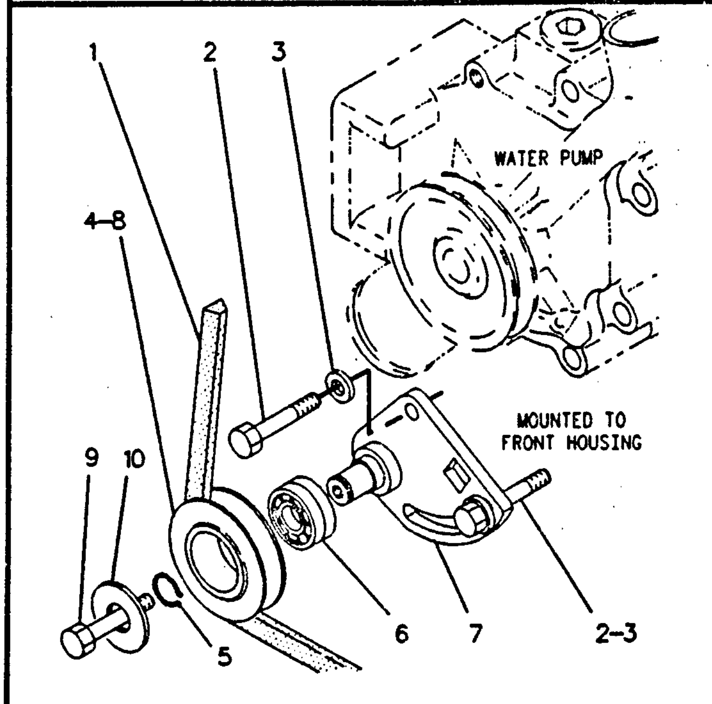


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C1493	1	VALVE-BYPASS					
	2	9L9188	1	SPRING-VALVE					
	3	5P8196	1	PLUG-O-RING					
	4	2M9780	1	SEAL-O-RING					
	5	7C1162	1	GASKET					
	6	7C1163	1	GASKET					
M	7	8T0276	7	BOLT					
	8	7W9026	1	BASE-OIL COOLER					
M	9	6V5218	6	BOLT					
	10	9M1974	13	WASHER					
	11	4W9181	1	CORE AS-OIL COOLER					
	12	8M4445	2	SEAL-O-RING					

M-METRIC PART

A-457134 EP

COOLING SYSTEM



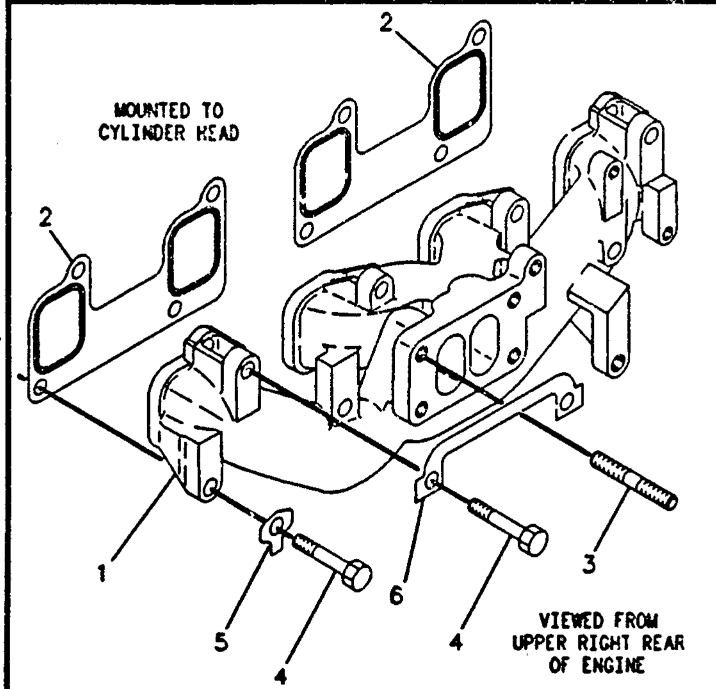
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6I6384	1	V-BELT
M	2	6V2317	2	BOLT
	3	9M1974	2	WASHER
	4	7E5713	1	PULLEY AS-IDLER
	5	2L8509	1	RING-LOCK
	6	8E0451	2	BEARING
	7	7W3779	1	PLATE AS-IDLER
	8	7W3850	1	PULLEY-IDLER
M	9	6V5215	1	BOLT
	10	4F3714	1	WASHER

M-METRIC PART

F-498206 EF

1358 4W5428 DRIVE GP-WATER PUMP

AIR INLET AND EXHAUST SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
C	1	7E4238	1	MANIFOLD-EXHAUST
	2	7E8772	2	GASKET-MANIFOLD
M	3	8T7044	4	STUD
MC	4	6V7981	8	BOLT
	5	0L0364	4	LOCK
	6	7E9410	2	LOCK

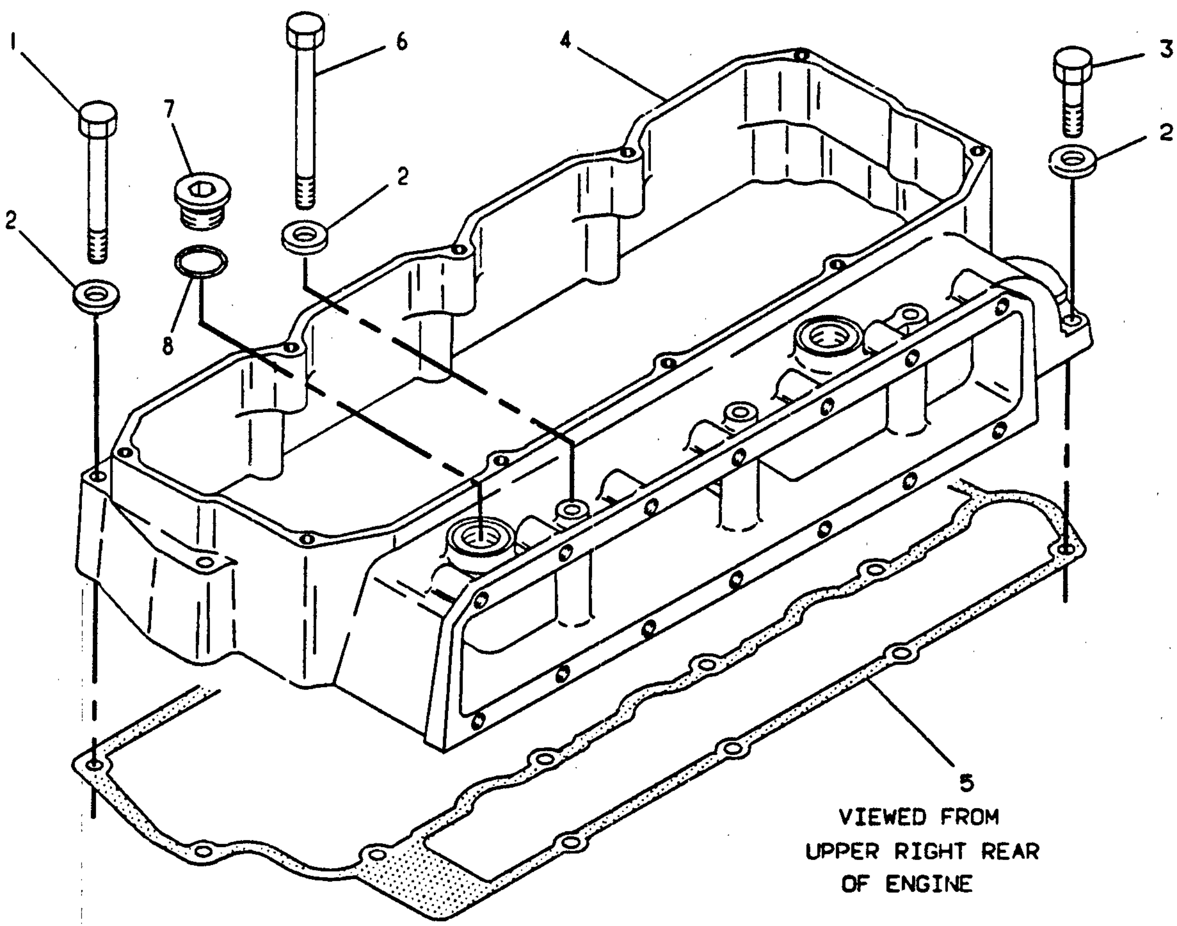
C-CHANGE FROM PREVIOUS TYPE
M-METRIC PART

F-495947 EP

1059 **1W8898 MANIFOLD GP-EXHAUST**

Requires 4W6609 Lines-Air & 4W6615 Lines-Turbocharger Oil

AIR INLET AND EXHAUST SYSTEM

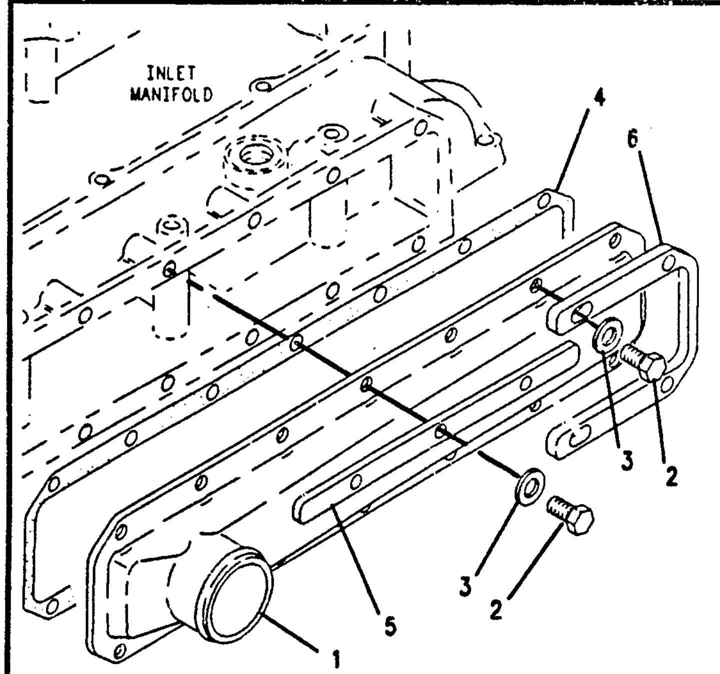


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	5P8347	11	BOLT					
	2	9M1974	15	WASHER					
M	3	6V5218	1	BOLT					
	4	7W7582	1	MANIFOLD-INLET					
	5	7W8903	1	GASKET					
M	6	6V5223	3	BOLT					
	7	9S8005	2	PLUG-O-RING					
	8	3K0360	2	SEAL-O-RING					

M-METRIC PART

A-457140 EP

AIR INLET AND EXHAUST SYSTEM

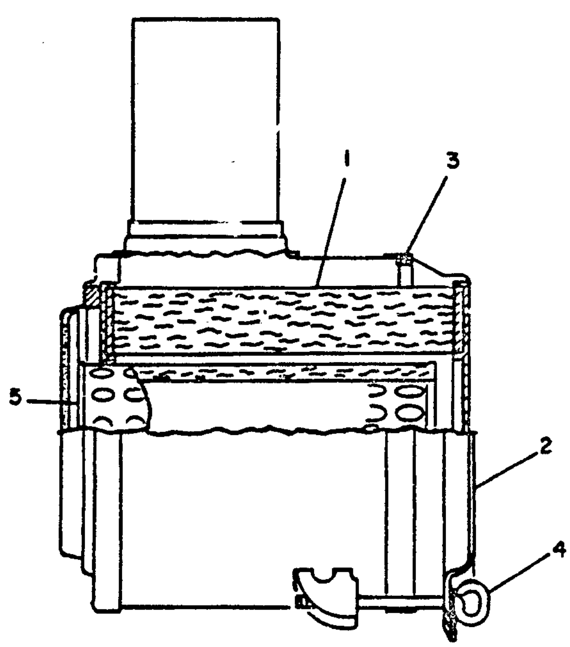


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7W9903	1	COVER-INLET MANIFOLD
M	2	6V5219	14	BOLT
	3	9M1974	14	WASHER
	4	7C1151	1	GASKET
	5	9Y7059	2	PLATE
	6	9Y6725	2	PLATE

M-METRIC PART

F-464023 EP

1038 7C2290 COVER GP-INLET MANIFOLD



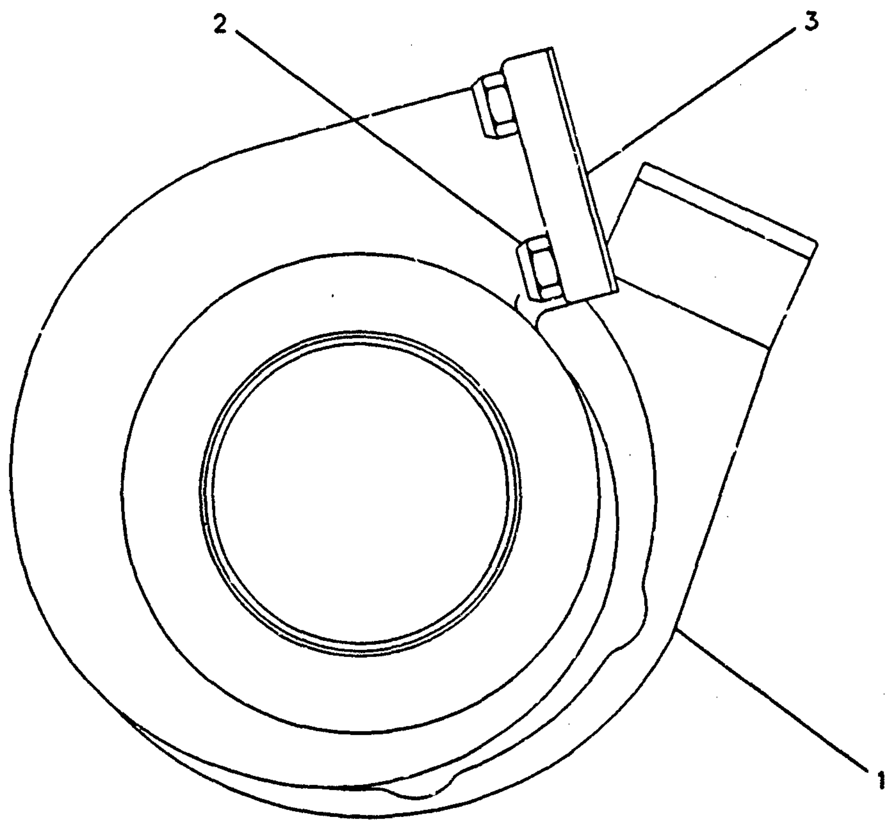
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7W3920	1	ELEMENT AS (PRIMARY)
	2	9M8512	1	CUP AS-AIR CLEANER
	3	9M8510	1	GASKET-AC CUP
	4	9M3695	2	ROD AS
	5	7C1062	1	ELEMENT AS-SECONDARY

B-466306 EP

1051 7C5519 AIR CLEANER GP

MEMORANDUM

MEMORANDUM

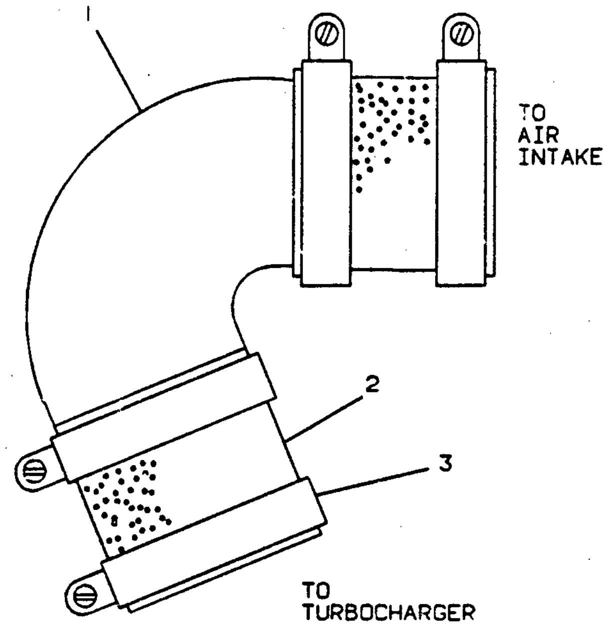


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7E9820	1	TURBOCHARGER GP					
		7E9819	1	HOUSING-TURBINE					
		1W4795	1	NAMEPLATE					
	2	9X6620	4	LOCKNUT					
	3	7C7431	1	GASKET-TURBOCHARGER					

F-497421 EP

7E5202 TURBOCHARGER GP

AIR INLET AND EXHAUST SYSTEM



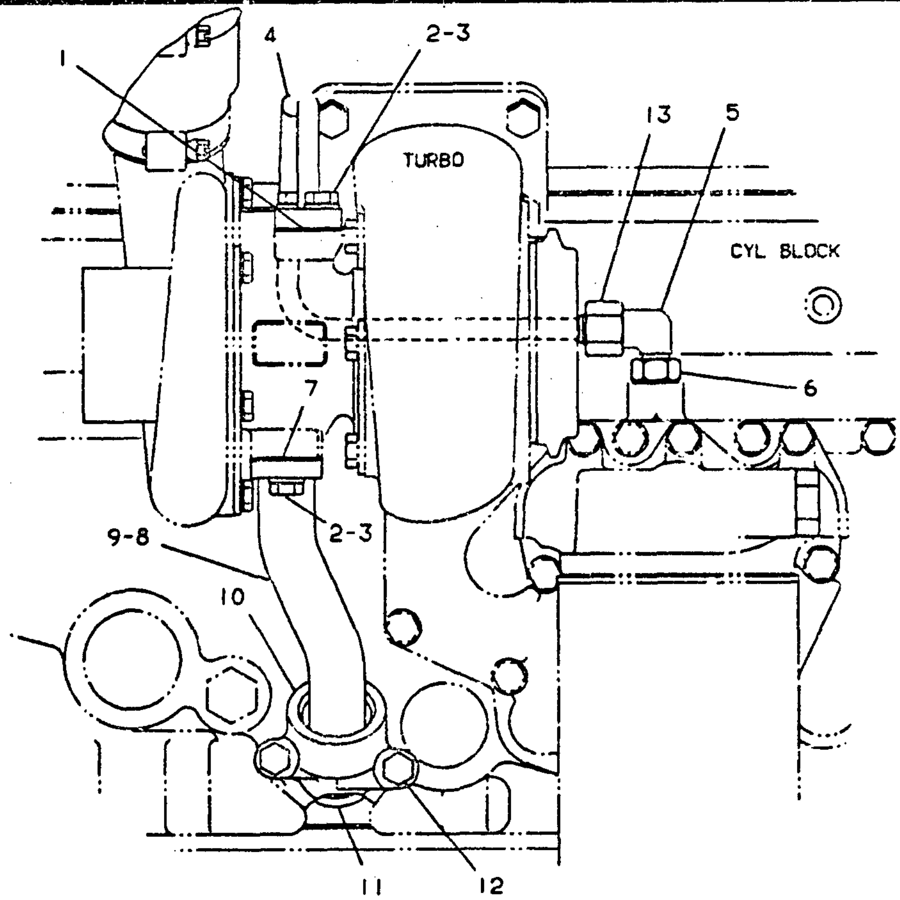
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9Y5459	1	ELBOW
	2	7C2519	2	HOSE
	3	5P0597	4	CLAMP

C-497410 EP

1058

4W6609 LINES GP-AIR
For Use With 1W8898 Manifold

AIR INLET AND EXHAUST SYSTEM



RIGHT SIDE VIEW

NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	1S7057	1	GASKET					
M	2	6V3940	4	BOLT					
	3	9M1974	4	WASHER					
	4	7C2309	1	TUBE AS					
	5	6V8724	1	ELBOW					
	6	3J1907	1	SEAL-O-RING 11.89MM(.468IN)ID					
	7	7W2398	1	GASKET					
	8	7C2307	1	TUBE AS					
	9	9M4849	1	SEAL-O-RING 23.16MM(.92IN)ID					
	10	7W2397	1	ADAPTER					
	11	4F7391	1	SEAL-O-RING 32.92MM(1.30IN)ID					
M	12	8T0276	2	BOLT					
	13	6V8397	1	SEAL-O-RING 10.21MM(.401IN)ID					

M-METRIC PART

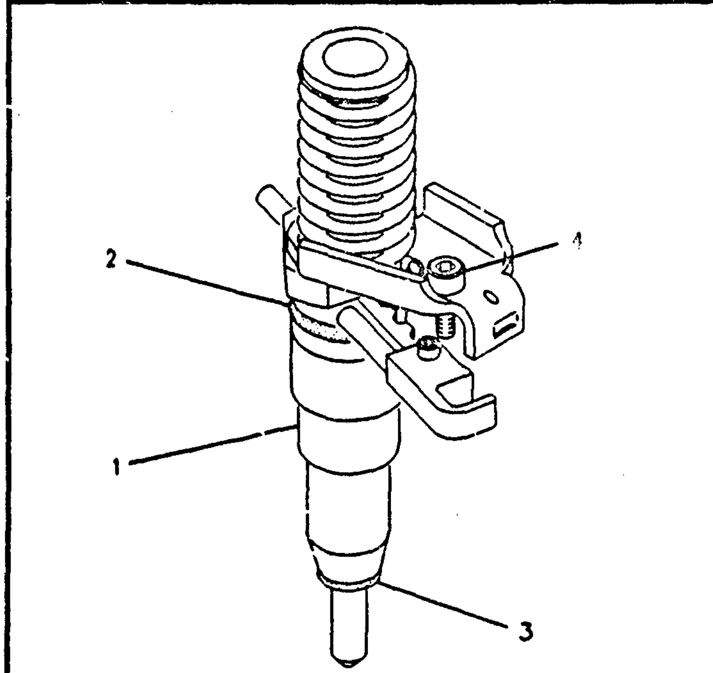
C-457219 EP

1307

4W6615 LINES GP-TURBOCHARGER OIL
For Use With 1W8898 Manifold

MEMORANDA

FUEL SYSTEM

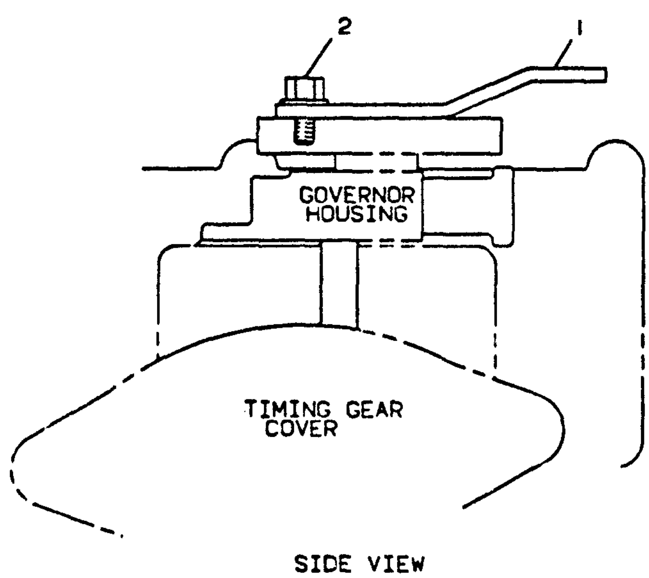


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7E9585	1	INJECTOR GP-FUEL
	2	6V6228	1	SEAL-O-RING
	3	328970	1	SEAL-O-RING
M	4	3T0849	1	BOLT-SOCKET HEAD

M-METRIC PART

F-497328 EP

7E9711 PUMP GP-FUEL INJECTION-4 REQUIRED



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C5202	1	LEVER
M	2	5C9553	1	BOLT
		8T4205	1	WASHER

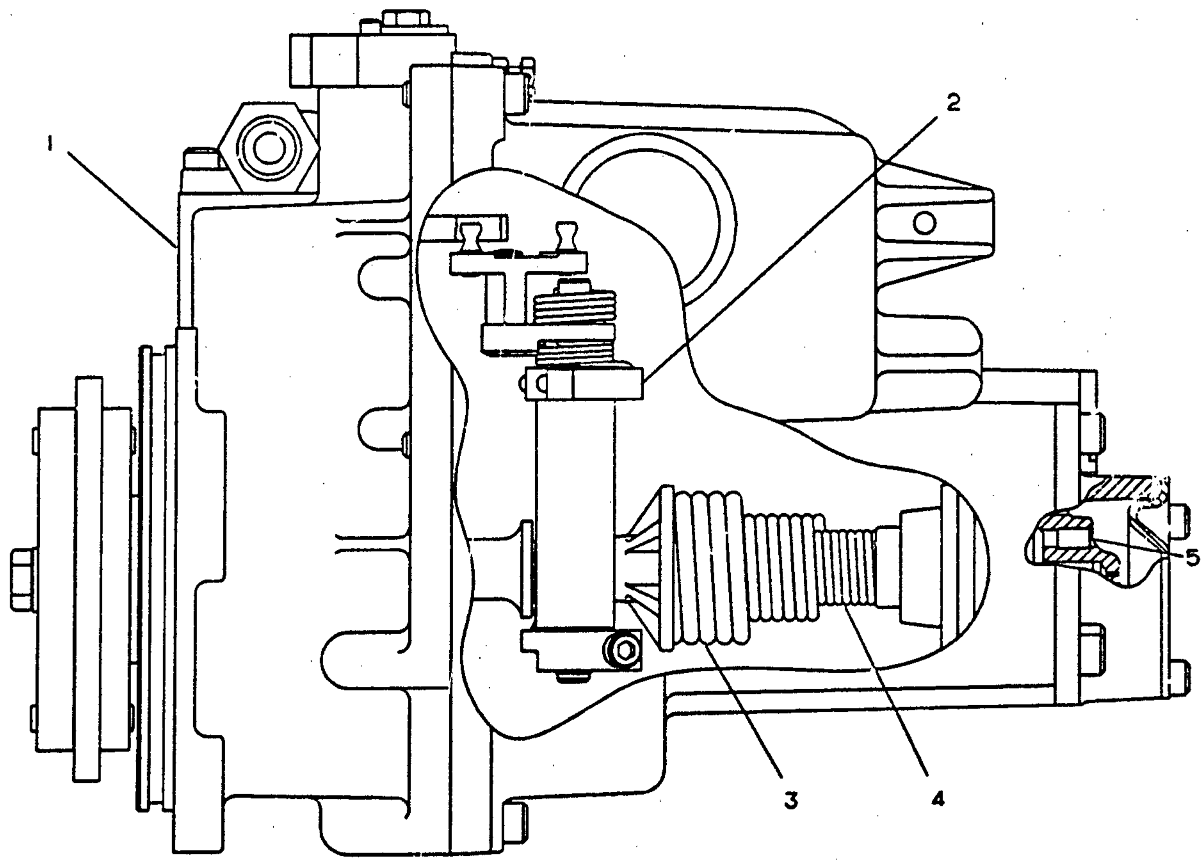
M-METRIC PART

C-494874 EP

1265

7C5201 CONTROL GP-GOVERNOR

FUEL SYSTEM

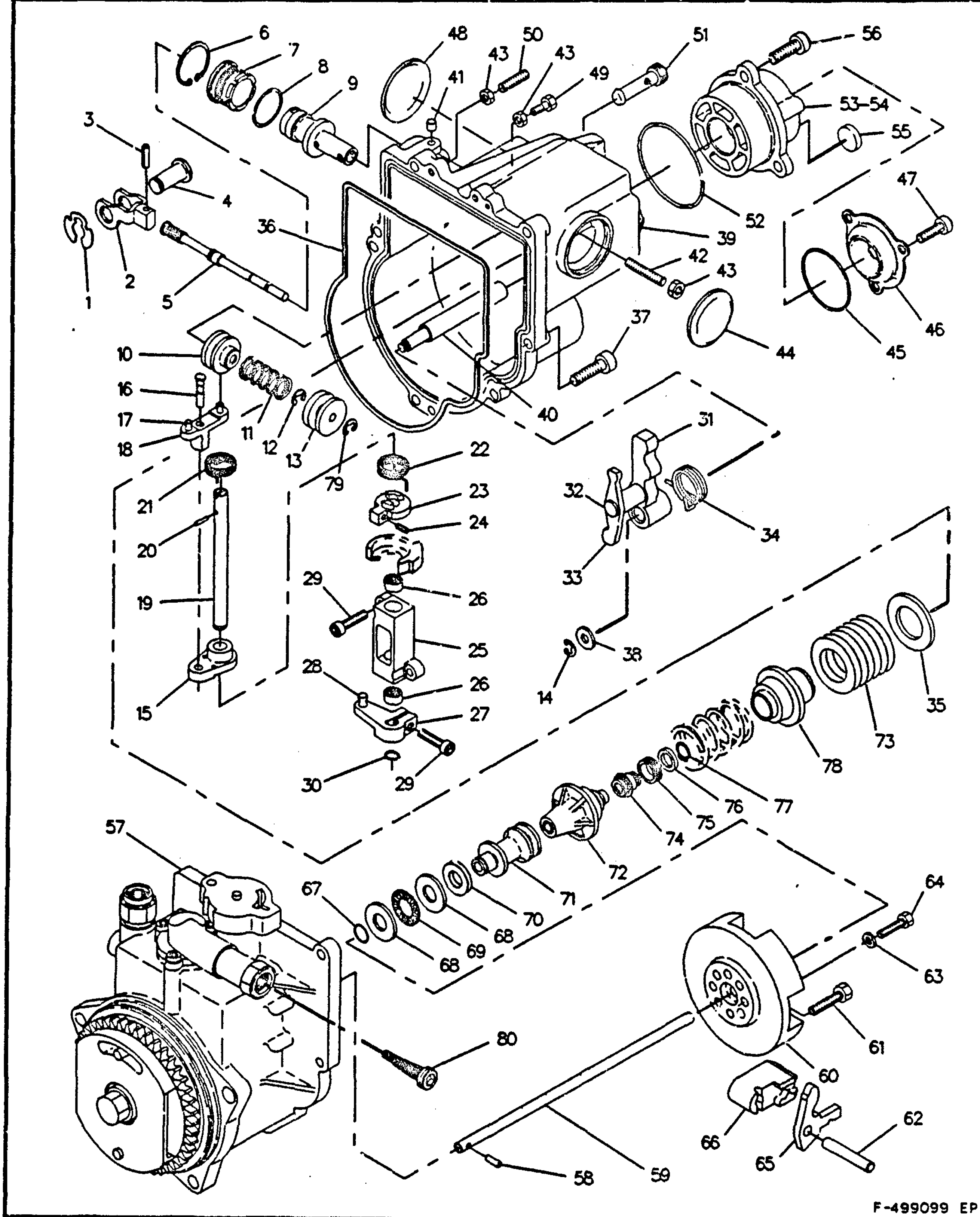


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
CY	1	4P4778	1	GOVERNOR GP-UNIT INJECTOR					
	2	7W4319	1	CAM-TORQUE					
	3	4P2558	1	SPRING GP					
	4	7C4466	1	SPRING-DASHPOT					
	5	9Y6726	1	PLUG-ORIFICE					

C-CHANGE FROM PREVIOUS TYPE
Y-SEPARATE ILLUSTRATION

C-499097 EP

FUEL SYSTEM



4P4778 GOVERNOR GP-UNIT INJECTOR
Part Of 9Y3833 Governor-Unit Injector

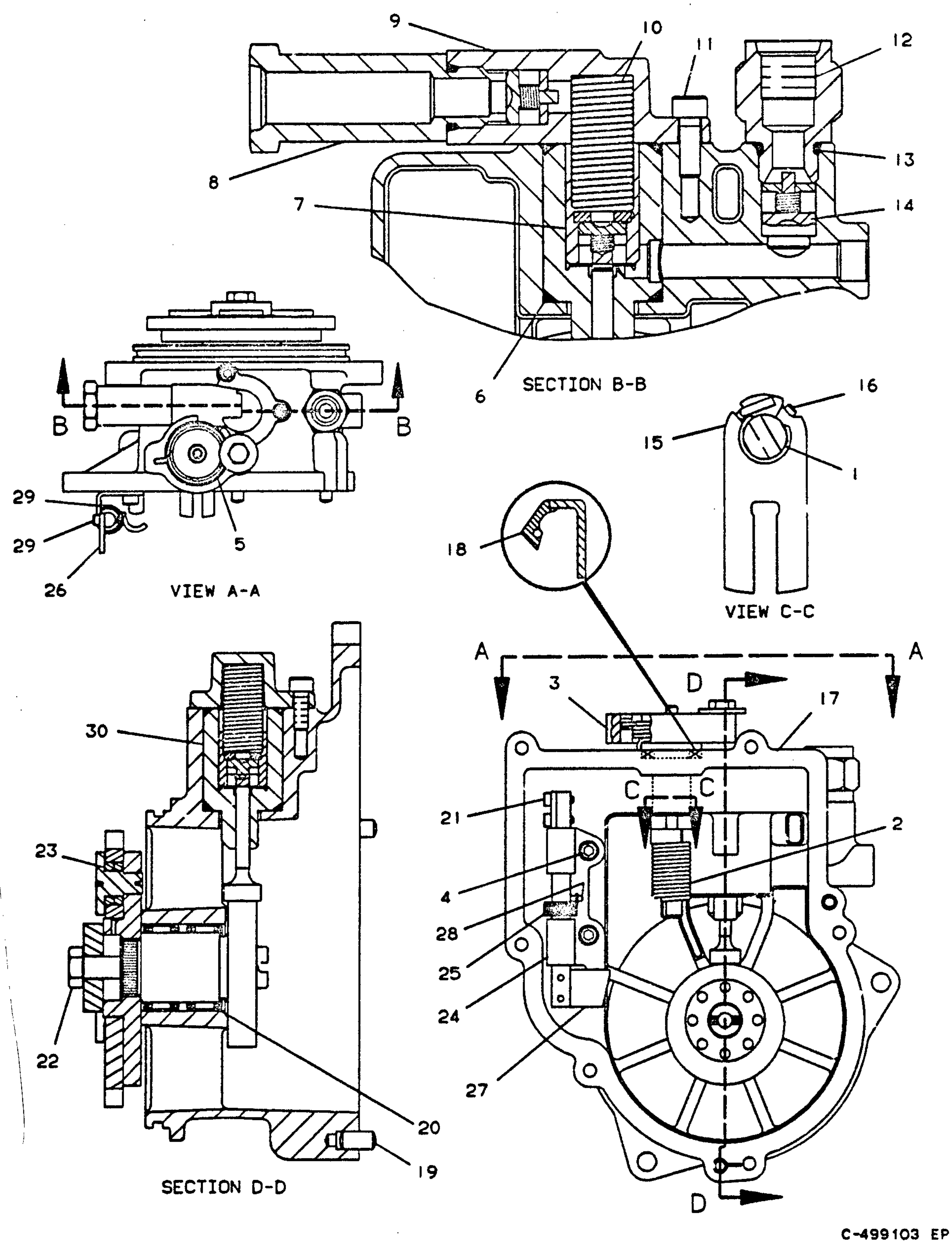
FUEL SYSTEM

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	8T1460	1	RING-RETAINING
	2	7C8974	1	CLEVIS AS
	3	4H1641	1	PIN-SPRING
	4	7C8854	1	PIN-CLEVIS
	5	7W7363	1	VALVE-GOVERNOR SERVO
	6	8C3312	1	RING-RETAINING
	7	7W7364	1	SLEEVE-GOVERNOR SERVO
	8	5P9757	1	SEAL-O-RING
	9	7W7362	1	PISTON-GOVERNOR SERVO
	10	4P4983	1	SLEEVE
	11	9Y1837	1	SPRING
	12	8T5447	1	RING-RETAINING
	13	7W5572	1	SLEEVE-LIMITING
	14	8T7060	1	RING-RETAINING
	15	7C0797	1	LEVER AS-SHAFT
Z	16		1	PIN
Z	17		2	SWIVEL
Z	18		1	LEVER
	19	7W5594	1	SHAFT AS-PIVOT
Z	20		1	PIN
	21	7C5480	1	SPRING-TORSION
	22	7C8640	1	SPRING-CAM
	23	7C6592	1	ARBOR AS-TORQUE CAM
M	24	8C6775	1	SETSCREW-SOCKET
	25	7W5608	1	BLOCK AS-BEARING
Z	26		2	BEARING-NEEDLE
	27	7W5560	1	LEVER AS-RISER
Z	28		1	SWIVEL
M	29	8C8580	2	BOLT-SOCKET HEAD
	30	3P3547	1	RING-RETAINING
	31	9Y8866	1	LEVER AS-LIMIT
Z	32		1	PIN
Z	33		1	LEVER
	34	7W9527	1	SPRING-TORSION
	35	7C5885	1	WASHER
	36	7W5614	1	SEAL-GOVERNOR HOUSING
M	37	3T0849	6	BOLT-SOCKET HEAD
	38	7W4313	1	WASHER
	39	7W8181	1	HOUSING AS-REAR
Z	40		1	SHAFT
Z	41		1	PLUG
M	42	8T6702	1	SETSCREW-SOCKET
M	43	3C6970	3	NUT
	44	7C6204	1	PLUG
	45	7L3386	1	SEAL-O-RING
	46	7C5884	1	COVER-OIL SUMP
M	47	6V5213	3	BOLT-SOCKET HEAD
	48	7C6205	1	PLUG
M	49	8T5435	1	BOLT
M	50	9X6002	1	SETSCREW
	51	7C4483	1	SCREEN AS
	52	6V5100	1	SEAL-O-RING
	53	7C6250	1	COVER AS
Z	54		1	COVER
Z	55		1	PLUG
M	56	8T0269	3	BOLT-SOCKET HEAD
Y	57	4P0666	1	DRIVE GP-GOV & TRANSFER PUMP
	58	7C5150	1	PIN
	59	7C5654	1	SHAFT-RISER
	60	7C5148	1	CARRIER-FLYWEIGHT
M	61	8C8546	9	BOLT-SOCKET HEAD
	62	2S7316	2	DOWEL
	63	6V7699	4	WASHER-HARD
M	64	8C8545	4	BOLT-SOCKET HEAD
	65	7C5541	2	TOE-FLYWEIGHT
	66	7W8993	2	WEIGHT
	67	8C5061	1	RING-RETAINING
	68	7C2743	2	RACE
	69	7W5561	1	BEARING-THRUST
B	70	7W1440	8	SHIM .12MM(.004IN)THK
	71	7W5583	1	RISER
	72	7C2421	1	SEAT AS-SPRING
B	73	7C5883	7	SHIM .25MM(009IN)THK
	74	7C3776	1	PISTON AS
Z	75		1	SPOOL
Z	76		1	RING-SPACER
Z	77		1	RING-RETAINING
	78	7W5591	1	SEAT-GOVERNOR SPRING
	79	9X2315	1	RING-RETAINING
	80	7E0155	1	SCREEN AS-FUEL INLET

B-USE AS REQUIRED
M-METRIC PART
Y-SEPARATE ILLUSTRATION
Z-NOT SERVICED SEPARATELY

499100 EP

4P4778 GOVERNOR GP-UNIT INJECTOR
4P4775-Page 52
Part Of 9Y3833 Governor-Unit Injector



4P4775 DRIVE GP-GOVERNOR & TRANSFER PUMP
Flexible Drive
Part Of 4P4778 Governor-Unit Injector

FUEL SYSTEM

NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6L8598	1	RING-RETAINING					
	2	7W9526	1	SPRING-TORSION					
	3	7W5568	1	SHAFT AS-THROTTLE					
M	4	6V5213	2	BOLT-SOCKET HEAD					
	5	7C5593	1	SPRING-THROTTLE BIAS					
	6	4D9986	2	SEAL-O-RING					
	7	4P3953	1	PISTON AS					
	8	7E0156	1	FITTING-INLET					
	9	7W5621	1	COVER-TRANSFER PUMP					
	10	7C5294	1	SPRING					
M	11	8C6364	3	BOLT-SOCKET HEAD					
	12	7W7381	1	FITTING-OUTLET					
	13	3J1907	2	SEAL-O-RING					
	14	7W7383	2	VALVE AS-CHECK					
	15	7W5571	1	LEVER-CONTROL					
M	16	8T7050	1	SETSCREW-SOCKET					
	17	4P0665	1	HOUSING AS-DRIVE					
	18	7S6798	1	SEAL-LIP TYPE					
	19	7S5005	2	DOWEL					
	20	2K5830	2	BEARING-NEEDLE					
	21	9Y0208	1	BUSHING					
M	22	9Y3107	1	BOLT					
	23	7X4805	6	SEAL-O-RING					
	24	7W9638	1	SHAFT AS-SHUT-OFF					
	25	7W4328	1	SPRING-SHUT-OFF					
	26	7W9402	1	LEVER-SHUT-OFF					
	27	7W9403	1	LEVER-SHUT-OFF					
	28	8C5899	1	PIN-SPRING					
M	29	8T5433	4	BOLT-SOCKET HEAD					
	30	7W5615	1	SLEEVE AS-PUMP					

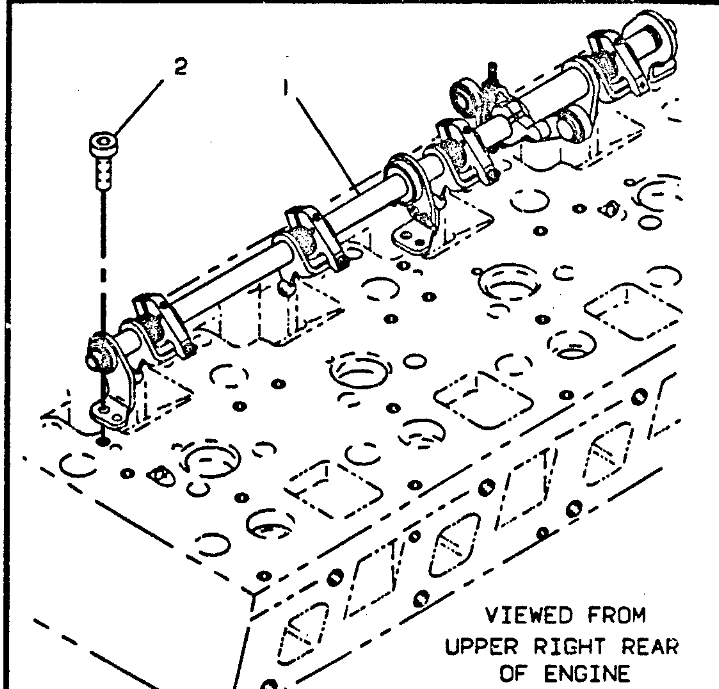
M-METRIC PART

499104 EP

1288

4P4775 DRIVE GP-GOVERNOR & TRANSFER PUMP
Flexible Drive
Part Of 4P4778 Governor-Unit Injector

FUEL SYSTEM



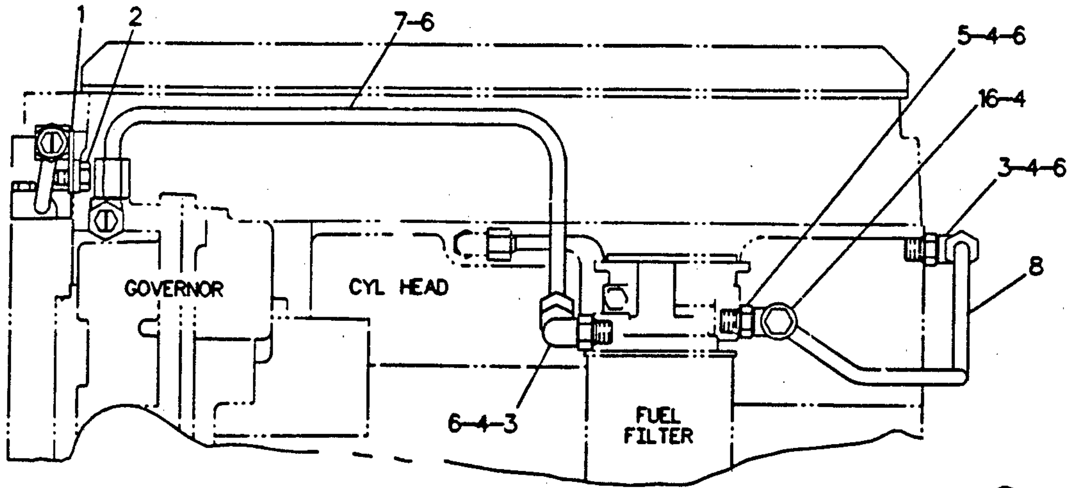
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7C1514	1	CONTROL AS-RACK
M	2	6V5683	3	BOLT

M-METRIC PART

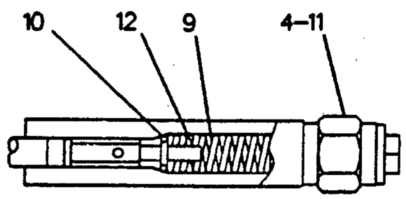
A-488633 EP

1298 **7W8600 CONTROL GP-FUEL INJECTION**

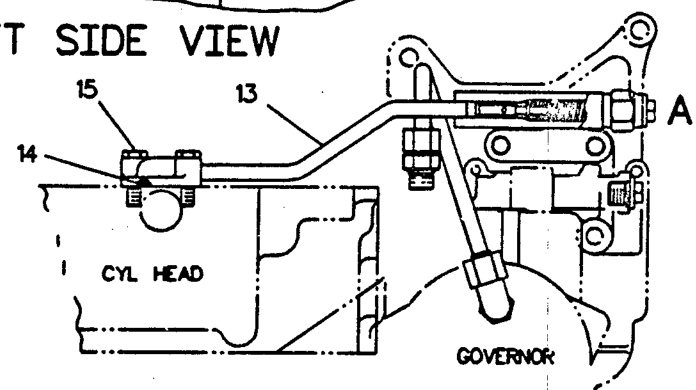
FUEL SYSTEM



LEFT SIDE VIEW



ENLARGED VIEW OF AREA A



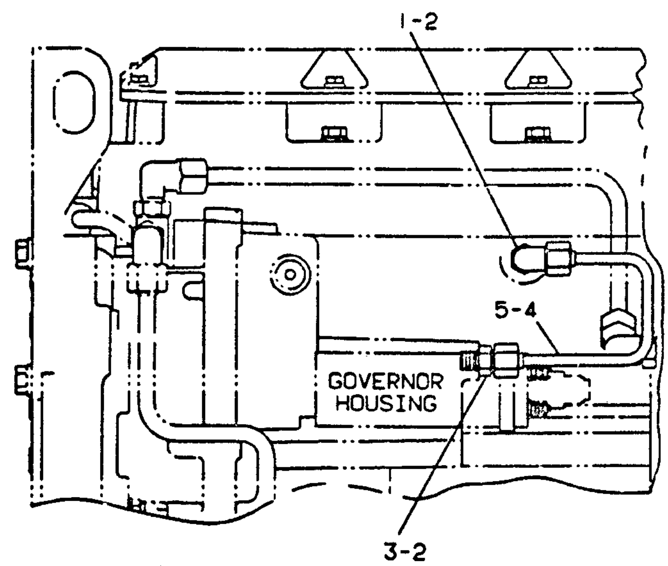
FRONT VIEW

NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	8T7934	2	WASHER-HARD					
M	2	6V6317	2	BOLT					
	3	6V8724	2	ELBOW					
C	4	3J1907	5	SEAL-O-RING (11.89MM ID)					
	5	9S4191	1	PLUG-O-RING					
	6	6V8397	4	SEAL-O-RING (9.25MM ID)					
C	7	7E6288	1	TUBE AS					
	8	7W7693	1	TUBE AS					
	9	3N3252	1	SPRING					
	10	5P7813	1	SEAL-O-RING					
	11	8T0151	1	ADAPTER-SPECIAL					
	12	7E5189	1	VALVE-REGULATING					
	13	7E5190	1	TUBE AS					
	14	5F7054	1	SEAL-O-RING					
MC	15	8T7547	2	BOLT					
	16	7X2459	1	TEE-SPECIAL					

C-CHANGE FROM PREVIOUS TYPE
M-METRIC PART

R-498221 EP

FUEL SYSTEM



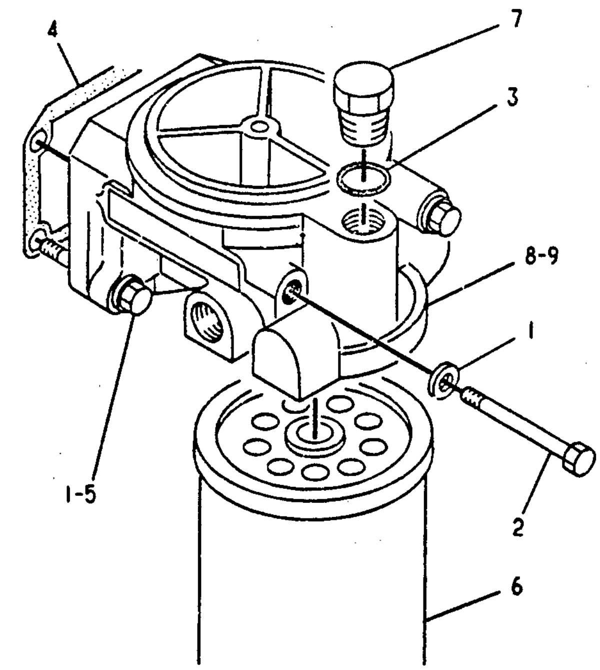
LEFT SIDE VIEW

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6V8628	1	ELBOW
	2	3J7354	2	SEAL-O-RING (8.92MM ID)
	3	6V8647	1	CONNECTOR-SEAL
	4	7W0367	1	TUBE AS
	5	4J5477	2	SEAL-O-RING (8.61MM ID)

R-494156 EP

1307 7W8434 LINES GP-GOVERNOR OIL

FUEL SYSTEM



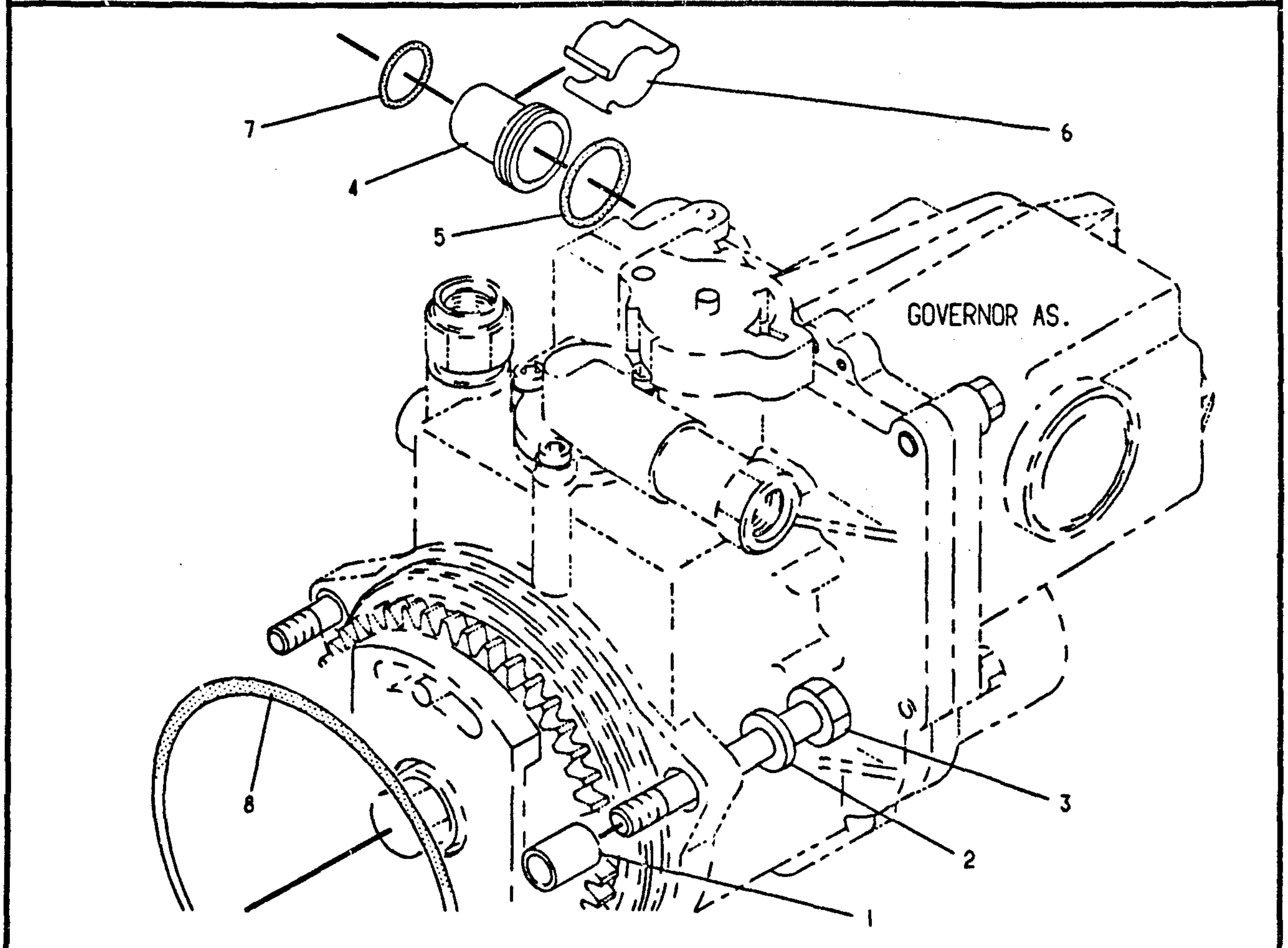
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9M1974	4	WASHER
M	2	6V9607	2	BOLT
	3	3J1907	1	SEAL-O-RING
	4	7C1159	1	GASKET
M	5	6V5218	2	BOLT
	6	1R0711	1	FILTER AS-FUEL
	7	9S4191	1	PLUG-O-RING
	8	4W5158	1	BASE AS
	9	4N329[illegible]	1	INSERT-FUEL FILTER

M-METRIC PART

A-512743 EP

1262 1N3476 FILTER GP-FUEL

FUEL SYSTEM



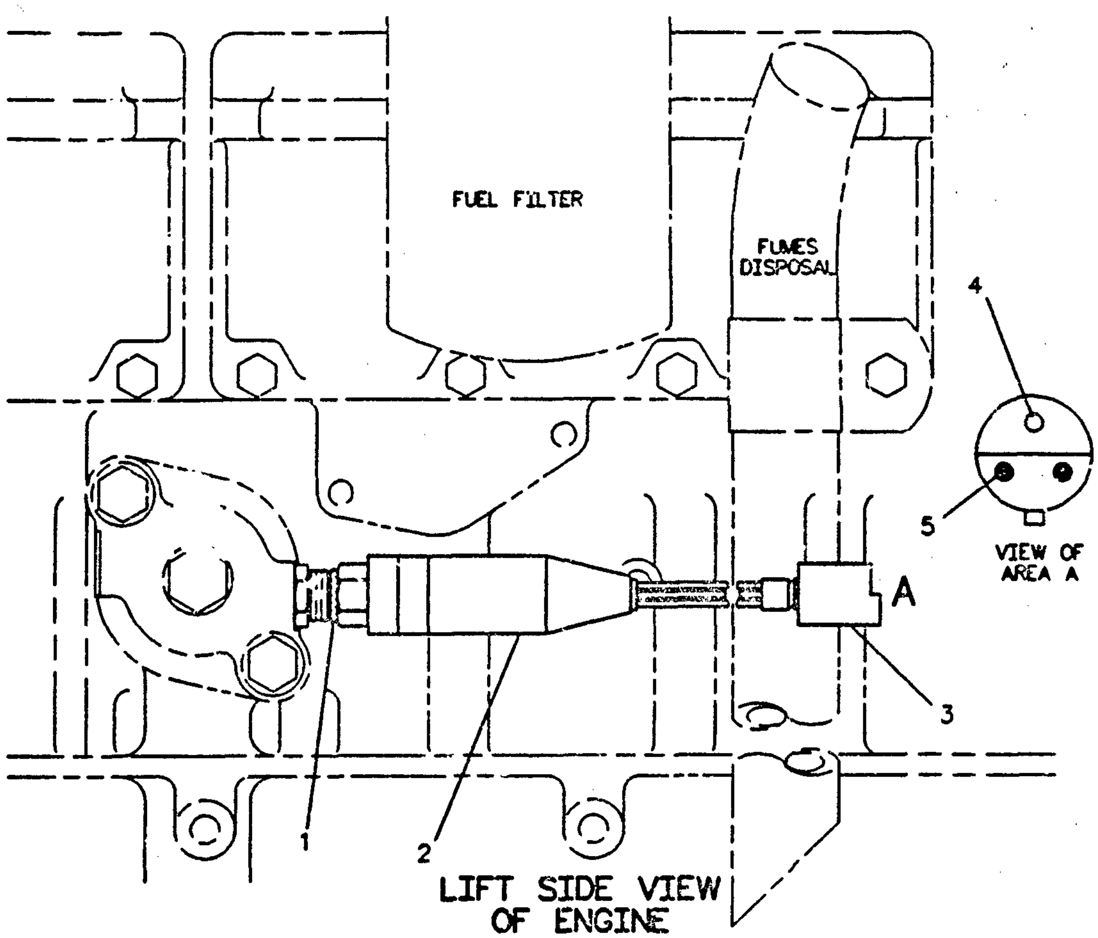
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
JC	1	7W3872	1	SLEEVE					
	2	9M1974	3	WASHER					
M	3	6V5218	3	BOLT					
C	4	9Y5295	1	TUBE-GOVERNOR CONNECTION					
	5	6F6673	1	SEAL-O-RING					
	6	7C3839	1	CLIP-SPRING					
	7	7E0844	1	SEAL					
	8	1T1068	1	SEAL-O-RING					
				J-INSTALL SLEEVE IN FRONT HOUSING					

C-CHANGE FROM PREVIOUS TYPE
M-METRIC PART

A-476378 EP

MEMORANDA

ELECTRICAL SYSTEM

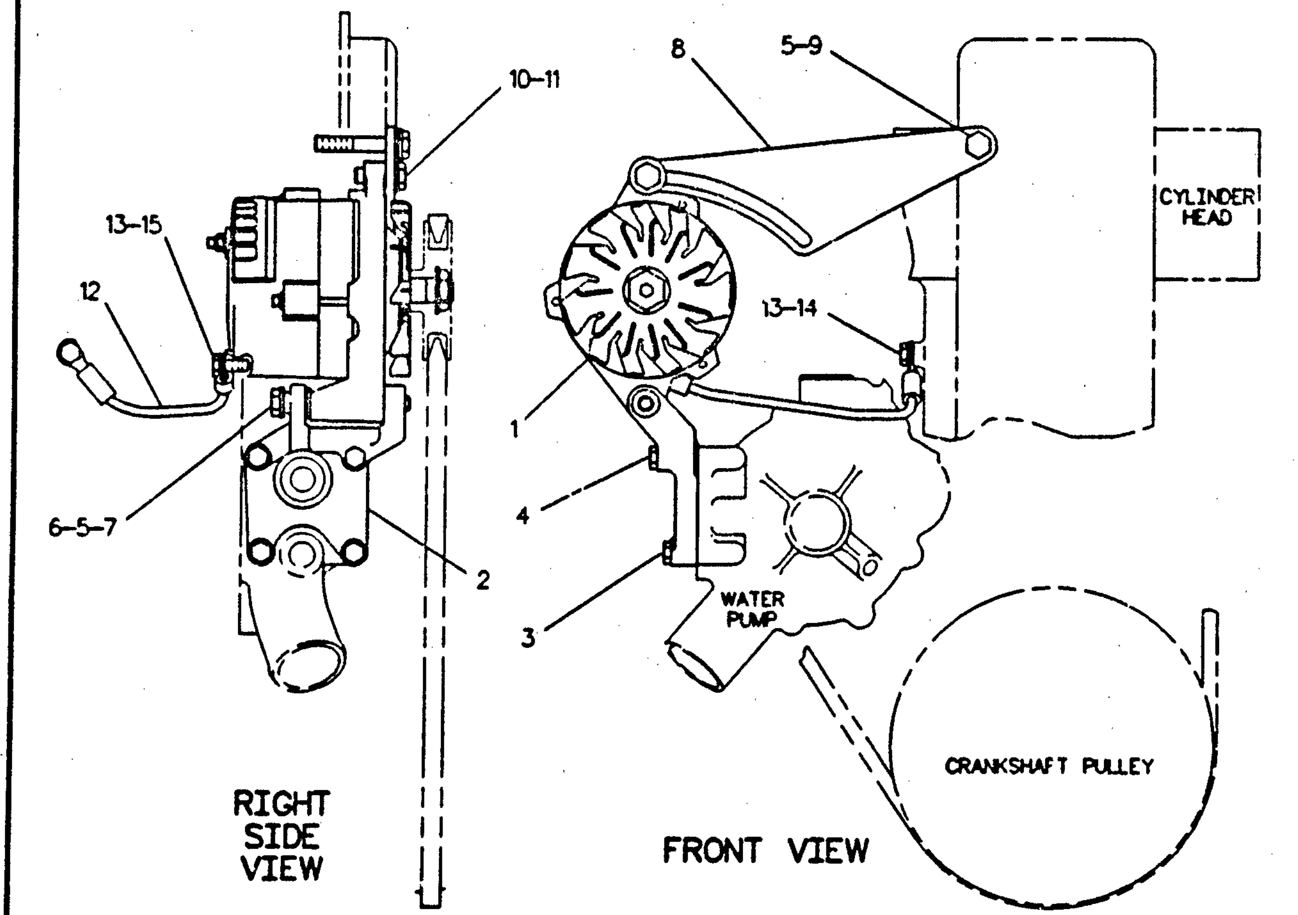


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3J1907	1	SEAL-O-RING					
	2	9X4276	1	SWITCH AS-PRESS ([illegible])					
	3	7N7781	1	HOUSING-RECEPT [illegible]					
	4	7N7779	1	SOCKET					
	5	7N7780	2	PIN-CONNECTOR					

F-498200 EP

7E9403 INSTRUMENT GP

ELECTRICAL SYSTEM



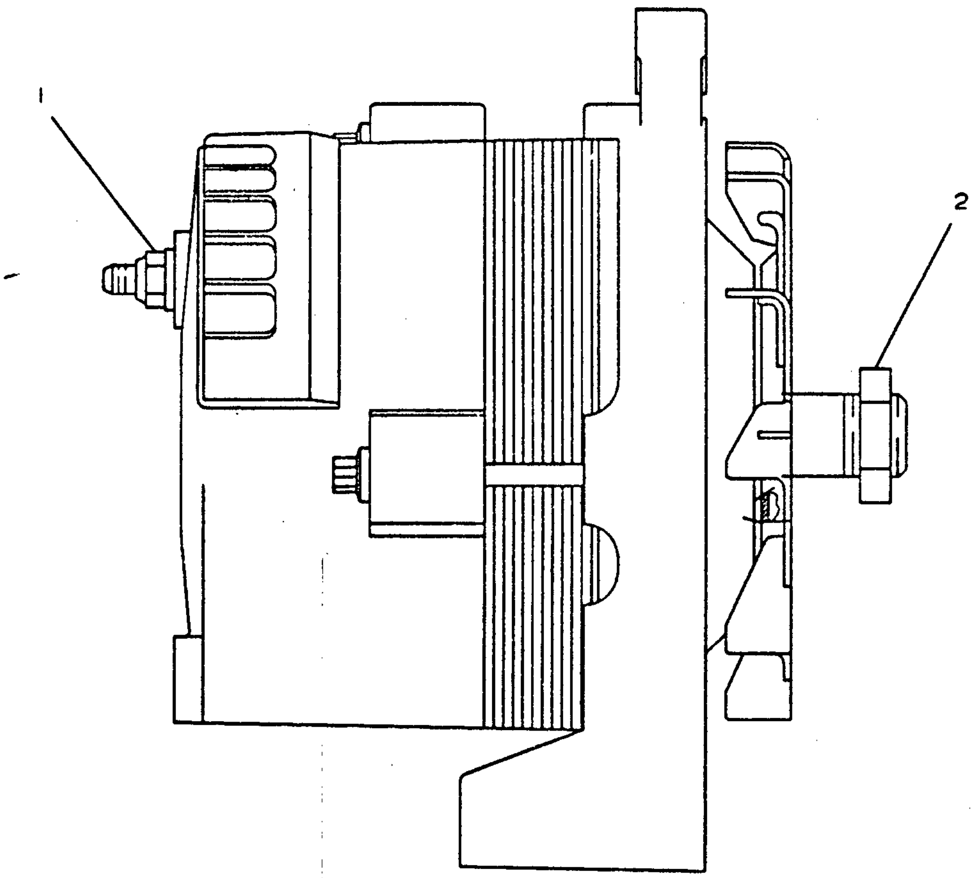
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	8C5510	1	ALTERNATOR GP-CHARGING					
	2	7W8807	1	BRACKET					
M	3	8T7547	2	BOLT					
M	4	8T4197	2	BOLT					
	5	8T4121	4	WASHER					
	6	9Y0083	1	SPACER					
M	7	8T4178	1	BOLT					
	8	9Y4197	1	STRAP-ALTERNATOR ADJUSTING					
M	9	8T6466	1	BOLT					
M	10	8T4908	1	BOLT					
	11	7X0579	1	WASHER-HARD					
	12	9Y7236	1	WIRE AS					
	13	8T4224	2	WASHER					
M	14	7X2536	1	BOLT					
M	15	8T4189	1	BOLT					

M-METRIC PART
Y-SEPARATE ILLUSTRATION

F-498123 EP

9Y7235 ALTERNATOR GP
12 Volt, 60 Ampere
8C5510-Page 62

ELECTRICAL SYSTEM



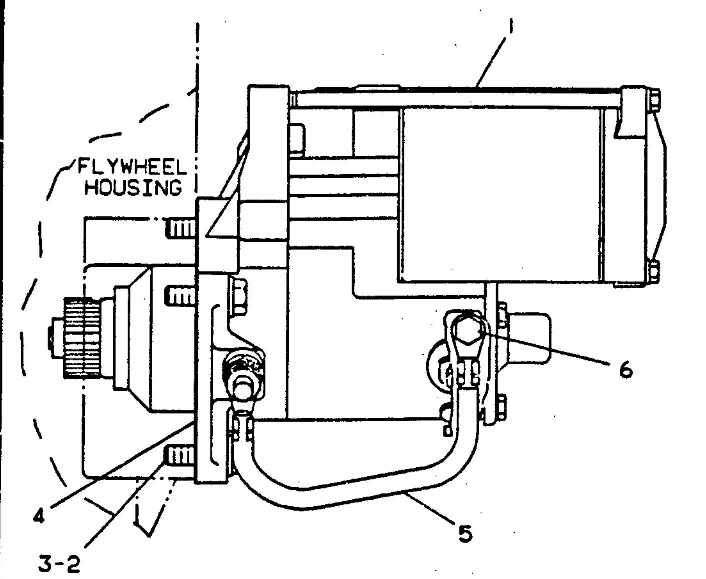
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	8T4134	1	NUT					
		1H3244	1	LOCKWASHER					
	2	2K4821	1	LOCKNUT					
		7F7621	1	WASHER					

M-METRIC PART

C-472618 EP

8C5510 ALTERNATOR GP-CHARGING-12 VOLT
Part Of 9Y7235 Alternator

ELECTRICAL SYSTEM



RIGHT SIDE VIEW

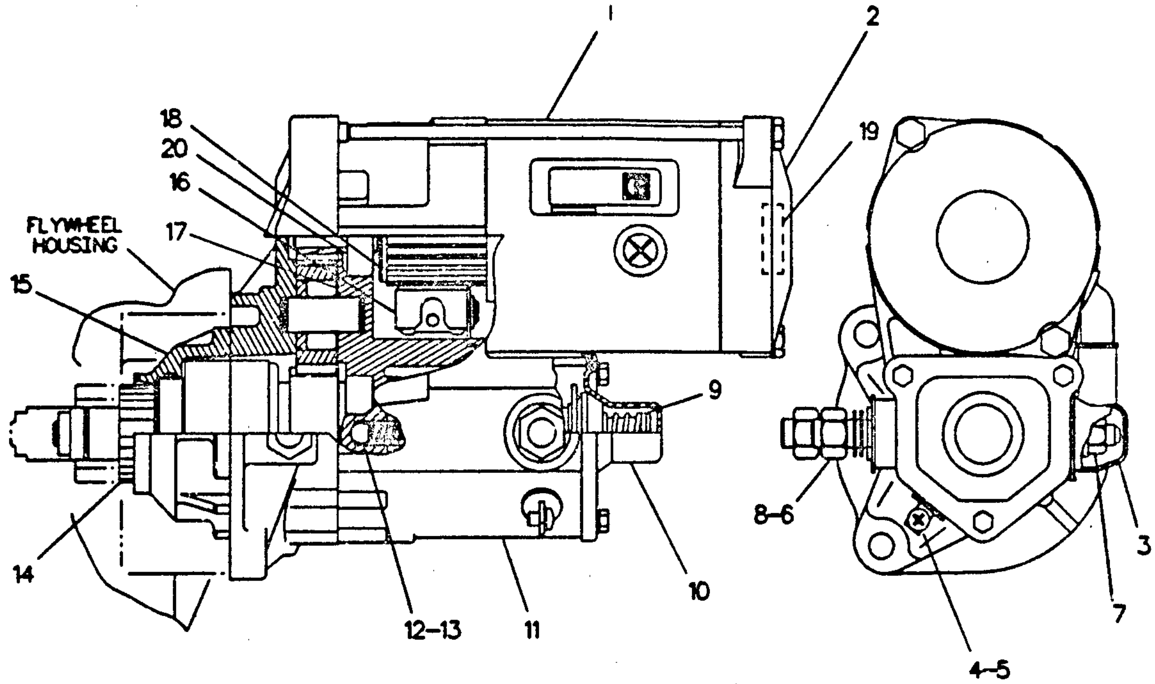
NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	9W2946	1	STARTING MOTOR GP-ELECTRIC
M	2	8T4196	3	BOLT
	3	8T4121	3	WASHER
	4	3K3257	1	GASKET
	5	9Y8241	1	WIRE AS
	6	8T4200	1	BOLT
		8T4224	1	WASHER

M-METRIC PART
Y-SEPARATE ILLUSTRATION

C-474599 EP

1453 7W8759 STARTING MOTOR GP-ELECTRIC-12 VOLT
9W2946-Page 64

ELECTRICAL SYSTEM



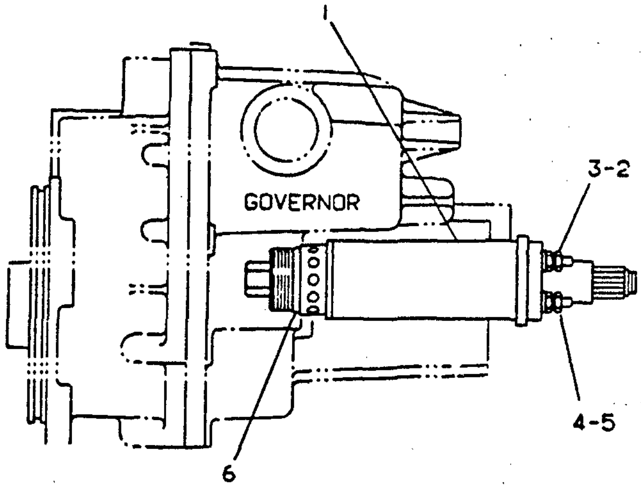
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9X1270	1	CASE AS-STARTER					THE FOLLOWING REPAIR KITS ARE AVAILABLE:
	2	9X1276	1	FRAME-STARTER					
	3	9X1278	1	BOOT			9X0295	1	KIT-TERMINAL
M	4	9X2036	1	SCREW-PAN HEAD					(INCL. NUTS, WASHERS
	5	8F1434	1	LOCKWASHER					BUSHINGS, SEALS,
M	6	8T4244	2	NUT					PLATES & TERMINALS)
M	7	8T4133	1	NUT					
		8T4121	1	WASHER			9X1285	1	KIT-BRUSH
	8	7X0562	2	WASHER-HARD					(INCL. BRUSHES &
	9	8C9778	1	PLUNGER AS					SCREWS)
	10	9X1277	1	COVER			9X1284	1	KIT-STARTER SEAL
	11	9X1274	1	SWITCH AS -STARTER					(INCL. SEALS &
	12	8J4455	1	BALL					GASKET)
	13	7T6090	1	SPRING			9X1283	1	KIT-HARDWARE
	14	9X1272	1	DRIVE AS-STARTER					(INCL. BOLTS, SCREWS
	15	9X1273	1	HOUSING-STARTER					NUT, WASHER &
	16	9X1275	1	HOLDER AS-BRUSH					LOCKWASHERS)
	17	7T6087	1	WASHER			9X1282	1	KIT-STARTER GEAR
	18	9X1271	1	ARMATURE AS					(INCL. PINIONS,
	19	2P8104	1	BEARING					ROLLERS & RETAINERS)
	20	8L4070	1	BALL BEARING					

M-METRIC PART

R-496149 EP

9W2946 STARTING MOTOR GP-ELECTRIC-12 VOLT
Part Of 7W8759 Starting Motor-Electric

ELECTRICAL SYSTEM



LEFT SIDE VIEW

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9X5512	1	SOLENOID AS
M	2	5C8312	2	NUT (SMALL)
	3	9B7233	2	LOCKWASHER (SMALL)
M	4	5C2874	1	NUT (LARGE)
	5	8F1434	1	LOCKWASHER (LARGE)
	6	4K1388	1	SEAL-O-RING

M-METRIC PART

C-489124 EP

1259

7C7695 SOLENOID GP-SHUT-OFF-12 VOLT
For Use With 12 Volt Latching Type Shutoff Solenoid

ENGINE RELATED PARTS

NOTE	PART NUMBER	QTY	DESCRIPTION	PAGE
NSS Y F	838073	1	ENGINE GROUP	67
NSS Y F	838087	1	ENGINE MOUNTING GROUP	68
NSS Y F	844141	1	ENGINE DRIVE SHAFT GROUP	73
NSS Y F	838111	1	RADIATOR GROUP	72
NSS Y F	815630	1	AIR CLEANER GROUP	71
NSS Y F	838870	1	EXHAUST GROUP	70
NSS Y F	838871	1	FUEL LINE GROUP	69
NSS Y F	4P5481	1	FAN SUCTION GROUP	34- 1

F - NOT SHOWN
Y - SEPARATE ILLUSTRATION
NSS - NOT SERVICED

P838088

REV 001

838088 POWER GROUP

ENGINE RELATED PARTS

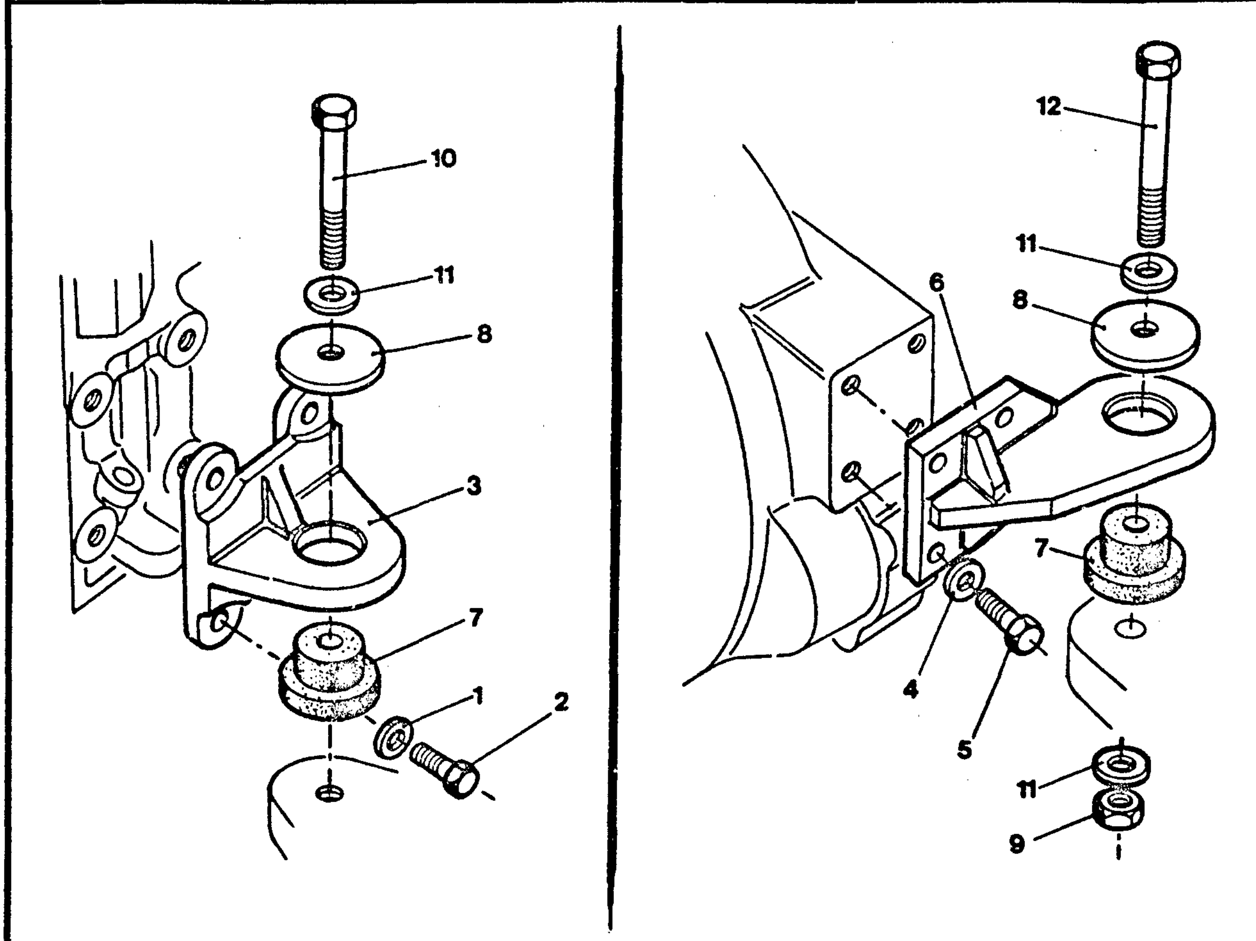
NOTE	PART NUMBER	QTY	DESCRIPTION	PAGE
NSS Y F	7C5477	1	ENGINE GROUP	2 and 3

F - NOT SHOWN
Y - SEPARATE ILLUSTRATION
NSS - NOT SERVICED

P838073
REV 000

838073 ENGINE GROUP
Part of 838088 Power Group

ENGINE RELATED PARTS



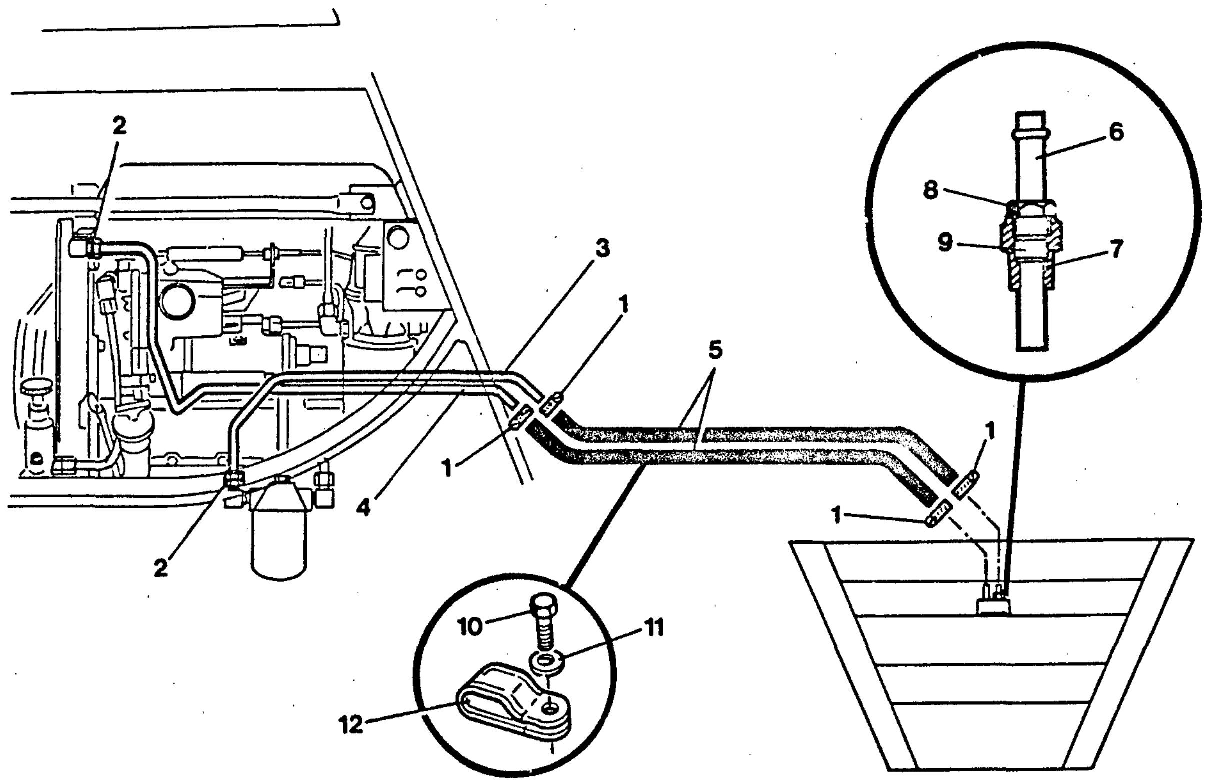
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V8765	8	WASHER		7	085018	4	MOUNTING AS.
M	2	8T0226	8	BOLT		8	086044	4	REBOUND WASHER
	3	9Y9241	2	SUPPORT BRACKET		9	6V8182	2	NUT
M	4	5P8247	8	WASHER		10	7X0370	2	BOLT
M	5	6V4429	8	BOLT		11	8T4994	6	WASHER
	6	815453	2	BRACKET - FLYWHEEL HOUSING		12	7X0375	2	BOLT

M - METRIC PART

P838087 Y
REV 001

838087 ENGINE MOUNTING GROUP
Part of 838088 Power Group

ENGINE RELATED PARTS



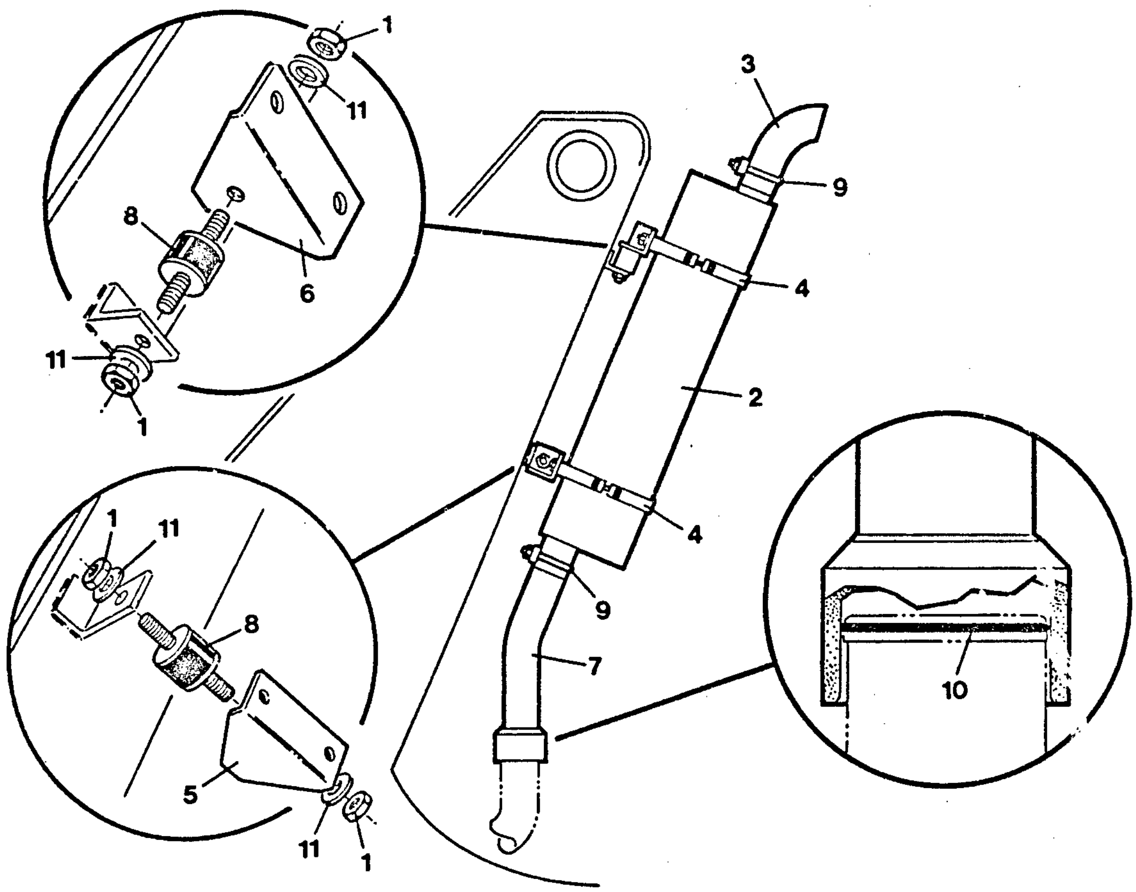
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	1P4278	4	CLAMP		7	897841	1	ADAPTOR
	2	6V8397	2	O RING		8	897980	1	TUBE NUT
	3	7E6781	1	TUBE		9	897983	1	SLEEVE
	4	7E6782	1	TUBE	M	10	8T0276	2	BOLT
	5	844228	2	HOSE	M	11	8T4224	2	WASHER
	6	844229	1	STANDPIPE		12	9S1350	2	CLIP

M - METRIC PART

P338871 Y
REV 003

838871 FUEL LINE GROUP
Part of 838088 Power Group

ENGINE RELATED PARTS



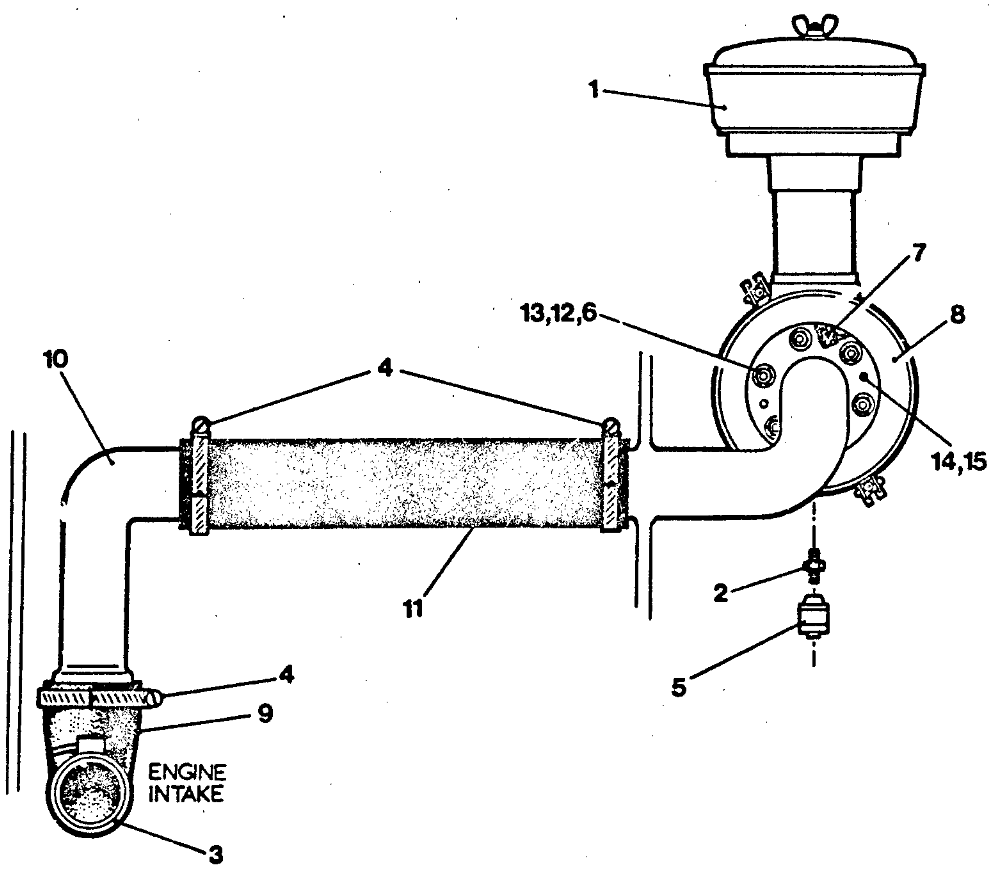
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	5C7261	4	NUT		7	838126	1	PIPE INLET EXHAUST
	2	815671	1	MUFFLER AS		8	838128	2	FLEXIBLE MOUNT
	3	815672	1	TAIL PIPE	M	9	897889	2	CLAMP
	4	815947	2	MOUNTING BAND		10	8F7559	1	SEAL
	5	838124	1	SUPPORT - SILENCER	M	11	8T4224	4	WASHER
	6	838125	1	SUPPORT - SILENCER					

M - METRIC PART

P836870 Y
REV001

838870 EXHAUST GROUP
Part of 838088 Power Group

ENGINE RELATED PARTS



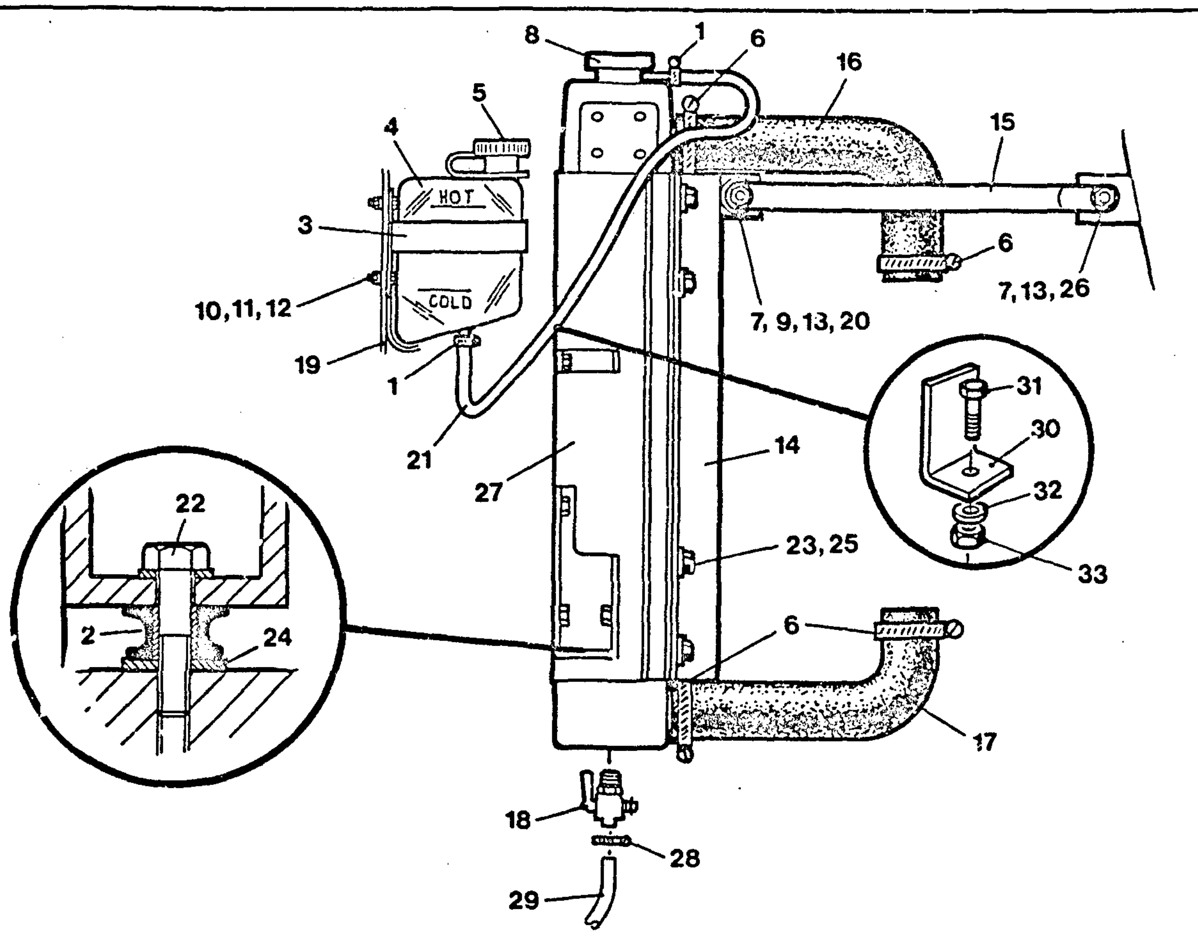
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	838977	1	PRE-CLEANER		9	7C7002	1	ELBOW
	2	5L3233	1	NIPPLE AS.		10	815623	1	PIPE - AIR INTAKE
	3	2J6540	1	CLAMP		11	815629	1	HOSE - FLEXIBLE
	4	5P0598	3	CLAMP	M	12	8T4121	6	WASHER
	5	663454	1	FILTER INDICATOR	M	13	8T4195	6	BOLT
M	6	6V7744	6	SELF LOCKING NUT	M	14	8T5095	2	WASHER
	7	7C1063	1	GASKET	M	15	8T0340	2	SOCKET HEAD SCREW
Y	8	7C5519	1	AIR CLEANER					

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P815630 Y
REV 004

815630 AIR CLEANER GROUP
7C5519 - PAGE 42
Part of 838088 Power Group.

ENGINE RELATED PARTS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	1P4278	2	CLAMP
	2	2W9710	2	MOUNT
	3	361863	1	BRACKET
	4	361864	1	RESERVOIR
	5	361866	1	RESERVOIR CAP AS.
	6	5P0597	4	HOSE CLIP
M	7	5P4116	8	WASHER
	8	6L8617	1	CAP AS.
	9	6R7696	1	BRACKET
M	10	8T0288	4	BOLT
M	11	6V7699	4	WASHER
M	12	6V9188	4	NYLOC NUT
M	13	6V9189	6	NYLOC NUT
	14	7E1358	1	SHIELD AS.
	15	815525	2	STAY
	16	815536	1	HOSE - TOP
	17	815537	1	HOSE - BOTTOM

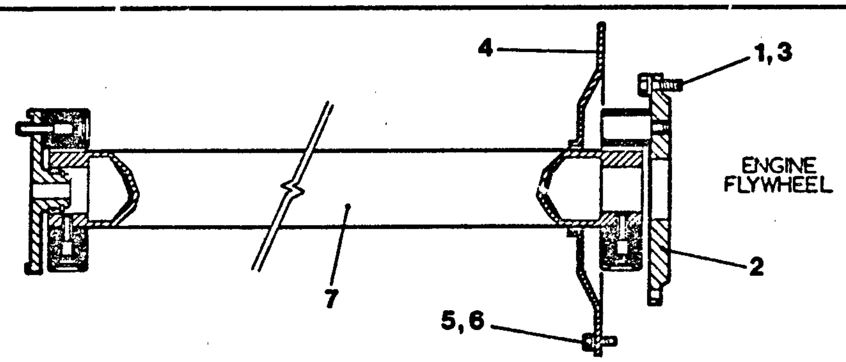
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	18	6R7923	1	DRAIN COCK
	19	6R8963	1	BRACKET
	20	897890	2	FLEXIBLE MOUNT
	21	8C3681	.75M	HOSE
M	22	8T4182	2	BOLT
M	23	8T4200	8	BOLT
M	24	8T4222	2	WASHER
M	25	5P4116	8	WASHER
M	26	8T4908	2	BOLT
	27	9Y7621	1	RADIATOR AS.
	28	1P4278	1	CLAMP
	29	6R7935	1	HOSE
	30	8Q2456	2	ANGLE
M	31	8T4189	2	BOLT
M	32	8T4224	2	WASHER
M	33	6V9189	2	NYLOC NUT

M - METRIC PART
D - ORDER BY THE METER

P838111 Y
REV 007

838111 RADIATOR GROUP
Part of 838088 Power Group

ENGINE RELATED PARTS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	5S7383	8	BOLT	M	5	8T4121	12	WASHER
	2	815694	1	FLANGE (FLYWHEEL)	M	6	8T4137	12	BOLT
M	3	8T4121	8	WASHER	Y	7	815696	1	FLEXIBLE COUPLING
	4	815695	1	DUST COVER					

M - METRIC PART

P844141 Y

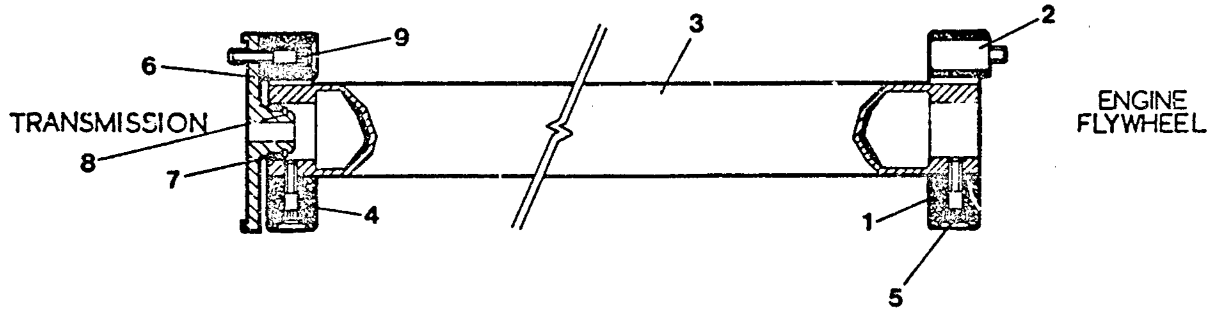
REV 001

844141 ENGINE DRIVE SHAFT GROUP

Part of 838808 Power Group

815696 - PAGE 74

ENGINE RELATED PARTS



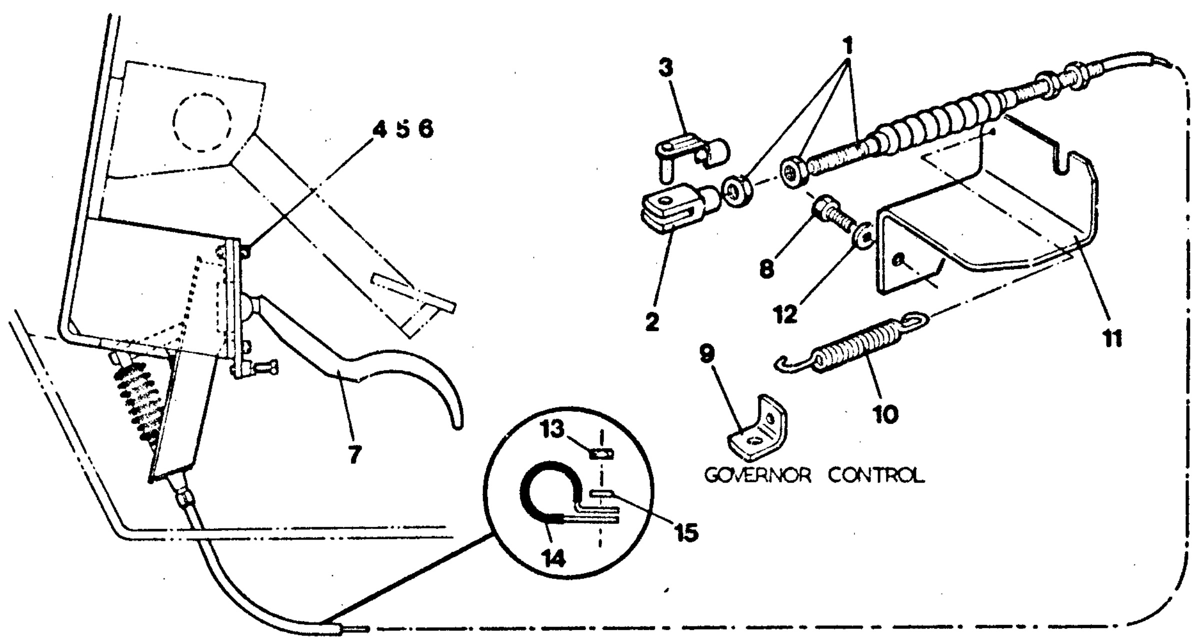
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9378	1	FLEXIBLE ELEMENT		6	6R9383	1	BEARING SUPPORT
	2	6R9379	3	S. PIN		7	6R9384	1	BEARING
	3	6R9380	1	TUBE AS.		8	6R9385	1	CIRCLIP
	4	6R9381	1	FLEXIBLE ELEMENT		9	5I0511	1	CAPSCREW
	5	6R9382	6	CAPSCREW					

P816696
REV 001

815696 FLEXIBLE COUPLING
Part of 844141 Engine Drive Shaft G.P.

74

ENGINE RELATED PARTS



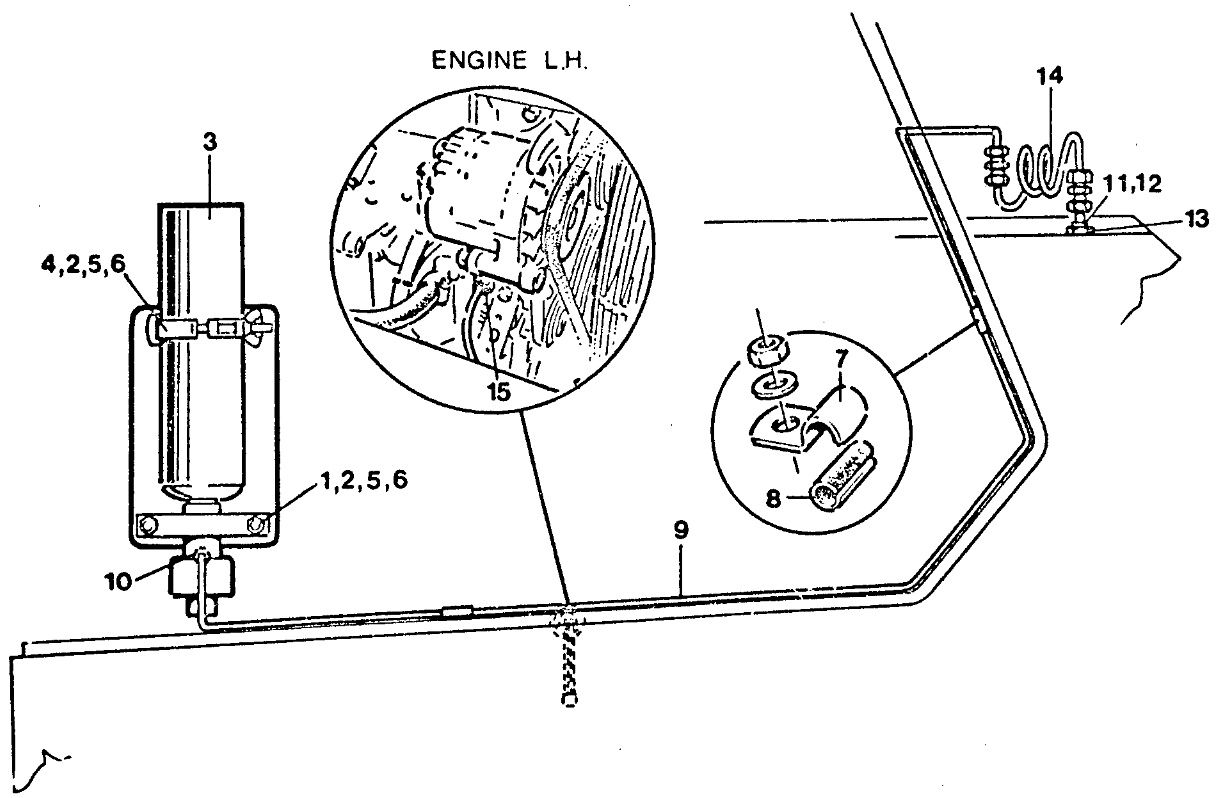
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	838754	1	THROTTLE CABLE		9	676982	1	BRACKET - SPRING
	2	897435	1	CLEVIS		10	677009	1	SPRING
	3	897436	1	SPRING PIN		11	6R7593	1	BRACKET - THROTTLE
M	4	8C8454	3	SCREW	M	12	8T4205	1	WASHER
M	5	6V7743	3	NYLOC NUT	M	13	6V7743	1	NYLOC NUT
M	6	8T4205	3	WASHER		14	815918	1	P. CLIP
	7	985534	1	THROTTLE PEDAL	M	15	8T4205	1	WASHER
M	8	5C9553	1	BOLT					

M - METRIC PART

P838454 Y
REV 002

838454 THROTTLE GROUP
Part of 6R7740 Open Cab Group

ENGINE RELATED PARTS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3T9493	1	VALVE AS		9	5P2929	1	TUBE
M	2	6V9189	2	NYLOC NUT		10	5P2948	1	CONNECTOR
	3	7N0296	1	CYLINDER AS.ETHER		11	3K0360	1	O. RING (O.R.B)
	4	7N2059	1	CLAMP AS.		12	6N9995	1	ATOMIZER
M	5	8T4189	2	BOLT		13	8J7844	1	ADAPTOR
M	6	8T4224	2	WASHER	B	14	7N0140	–	TUBE AS.
	7	4B0418	4	CLIP		15	8C3569	1	SWITCH AS.
	8	4D0623	4	GROMMET					

B - USE AS REQUIRED
M - METRIC PART

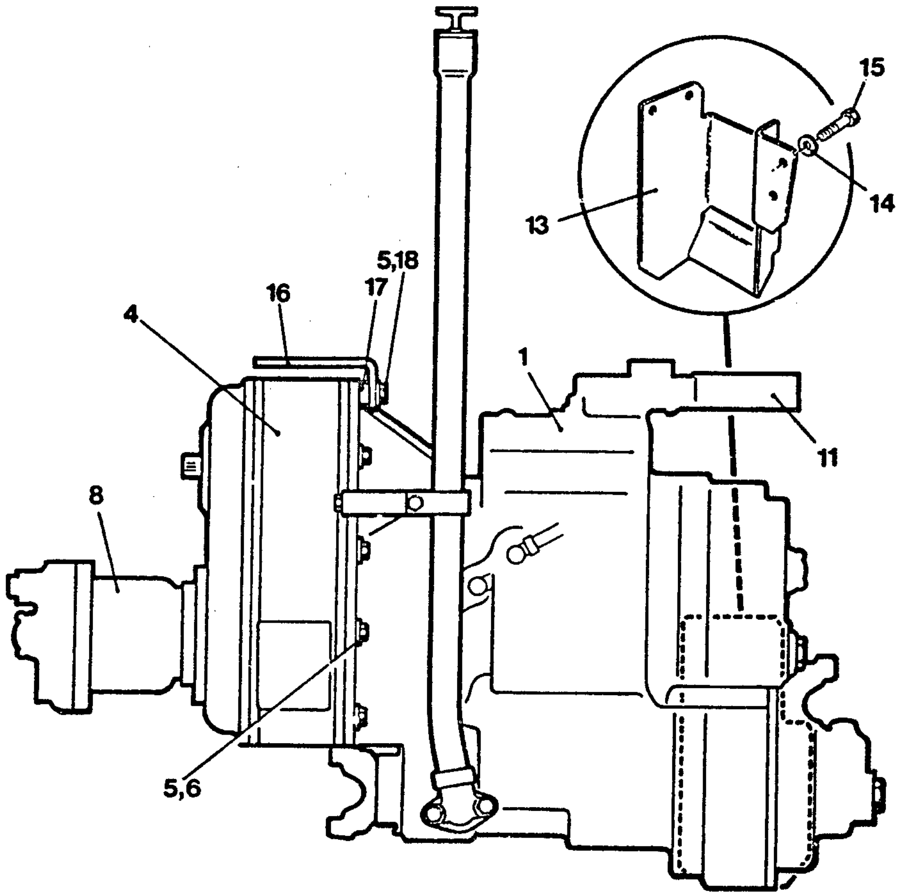
P816263 Y
REV 001

816263 ETHER START GROUP
Part of 838837 Cold Start Group

MEMORANDUM

MEMORANDUM

TRANSMISSION AND DRIVETRAIN



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y		6Y1617	1	TRANSMISSION (FIRST TYPE)	NSSY	F	838068	1	MOUNTING GROUP (TRANSMISSION)
	1	OR			NSSY	F	838450	1	TRANSMISSION PIPING GROUP
		8E9511	1	TRANSMISSION (SECOND TYPE)	NSSY	F	6R8934	1	FILLER GROUP
MN	F	6V9189	6	NYLOC NUT		13	6R7495	1	BRACKET
MN	F	7X2537	6	BOLT	M	14	8T4121	2	WASHER
Y	4	8Q2699	1	GEARBOX GROUP	M	15	8T4195	2	BOLT
M	5	8T4121	11	WASHER		16	8Q2061	1	BRACKET A.S.
M	6	8T4196	9	BOLT		17	897338	2	SLEEVE
MN	F	8T4224	6	WASHER	M	18	8T4185	2	BOLT
Y	8	815514	1	HYDRAULIC PUMP GROUP					

F - NOT SHOWN
M - METRIC PART
N - USED TO ATTACHE OUTPUT SHAFT GROUP TO TORQUE CONVERTER

NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION

P837968 Y
REV 009

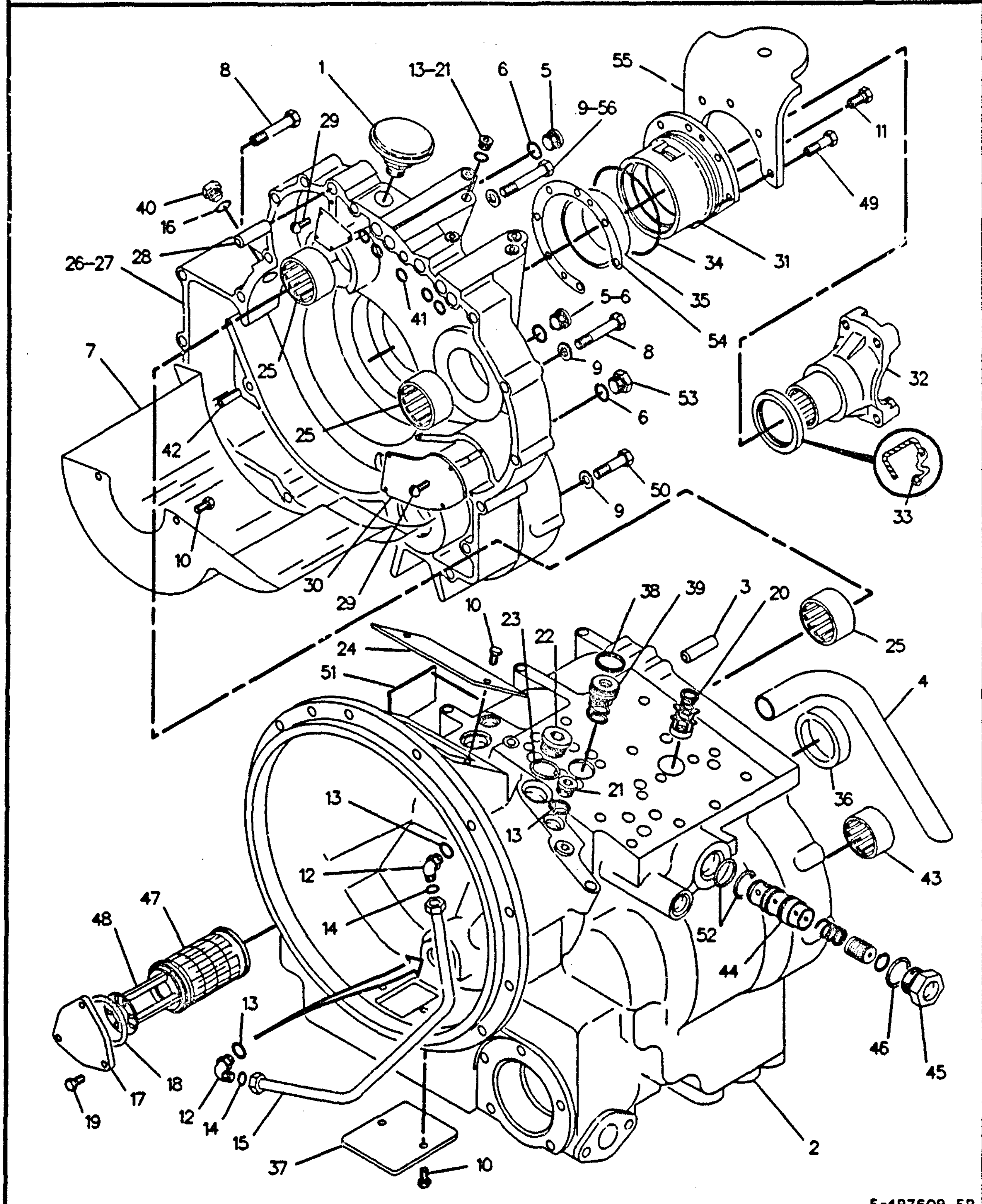
837968 TRANSMISSION GROUP

6Y1617 - PAGE 79, 8Q2699 - PAGE 102, 838068 - PAGE 105. 815514 - PAGE 156,
838450 - PAGE 106, 6R8934 - PAGE 107.

TRANSMISSION AND DRIVETRAIN

512741 P

TRANSMISSION AND DRIVETRAIN



6Y5635 CASE & PARTS GP
Part Of 6Y1617 Transmission Ar

TRANSMISSION AND DRIVETRAIN

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9G5127	1	BREATHER
	2	8E6388	1	CASE AS-TRANSMISSION
		9W7226	1	PLUG 15.9MM(.625IN)OD
		7T6496	3	PLUG 11.9MM(.468IN)OD
	3	6V7951	2	DOWEL
	4	9W1211	1	TUBE-SUCTION
	5	9S8008	2	PLUG-O-RING
	6	3D2824	3	SEAL-O-RING
	7	9W1458	1	BAFFLE AS
M	8	6V7981	13	BOLT
	9	6V8495	19	WASHER
M	10	6V5215	6	BOLT
M	11	6V1820	2	BOLT
	12	6V8724	2	ELBOW
	13	3J1907	9	SEAL-O-RING
	14	6V8397	2	SEAL-O-RING
	15	9W8232	1	TUBE AS
	16	7F0880	1	GASKET-COPPER
	17	9W1454	1	COVER
	18	5P3863	1	SEAL-O-RING
M	19	6V3940	3	BOLT
	20	9W1451	1	VALVE GP-RELIEF
	21	9S8004	7	PLUG-O-RING
	22	9S8005	1	PLUG-O-RING
	23	3K0360	1	SEAL-O-RING
	24	6T5514	1	COVER
	25	2W1141	3	BEARING
BD	26	8C8422		SEALANT
	27	8E6389	1	COVER AS
	28	6V7951	2	DOWEL
	29	4B4159	8	SCREW-DRIVE
	30	9W9076	1	PLATE
	31	9W1295	1	CAGE-BEARING
	32	9R4314	1	YOKE AS
	33	7K2830	1	SEAL-LIP TYPE
	34	5F3144	1	SEAL-O-RING
	35	1P2636	1	CUP-ROLLER BEARING
	36	7J8209	1	CUP-ROLLER BEARING
	37	9W7221	1	PLATE
	38	9X4609	1	SEAL-O-RING
	39	6Y2102	1	VALVE GP-RELIEF
	40	6T6044	1	PLUG
	41	8M5251	5	SEAL-O-RING
	42	2H9445	2	PIN-SPRING
	43	9W7948	1	BEARING-ROLLER
Y	44	9W7189	1	VALVE GP-FLOW CONTROL
	45	4S6679	1	ADAPTER-STRAIGHT THREAD
	46	2S4078	1	SEAL-O-RING
	47	8S9130	1	SCREEN-SUCTION
	48	8S9129	1	FILTER-MAGNETIC
M	49	6V5843	5	BOLT
M	50	6V4249	3	BOLT
	51	7X7650	1	PLATE-SERIAL NUMBER
	52	6V6228	2	SEAL-O-RING
	53	9S4183	1	PLUG
B	54	9W1296	1	SHIM PACK (INCL 12 SHIMS)
	55	6Y4466	1	BRACKET-MOUNTING
	56	8T0643	3	BOLT

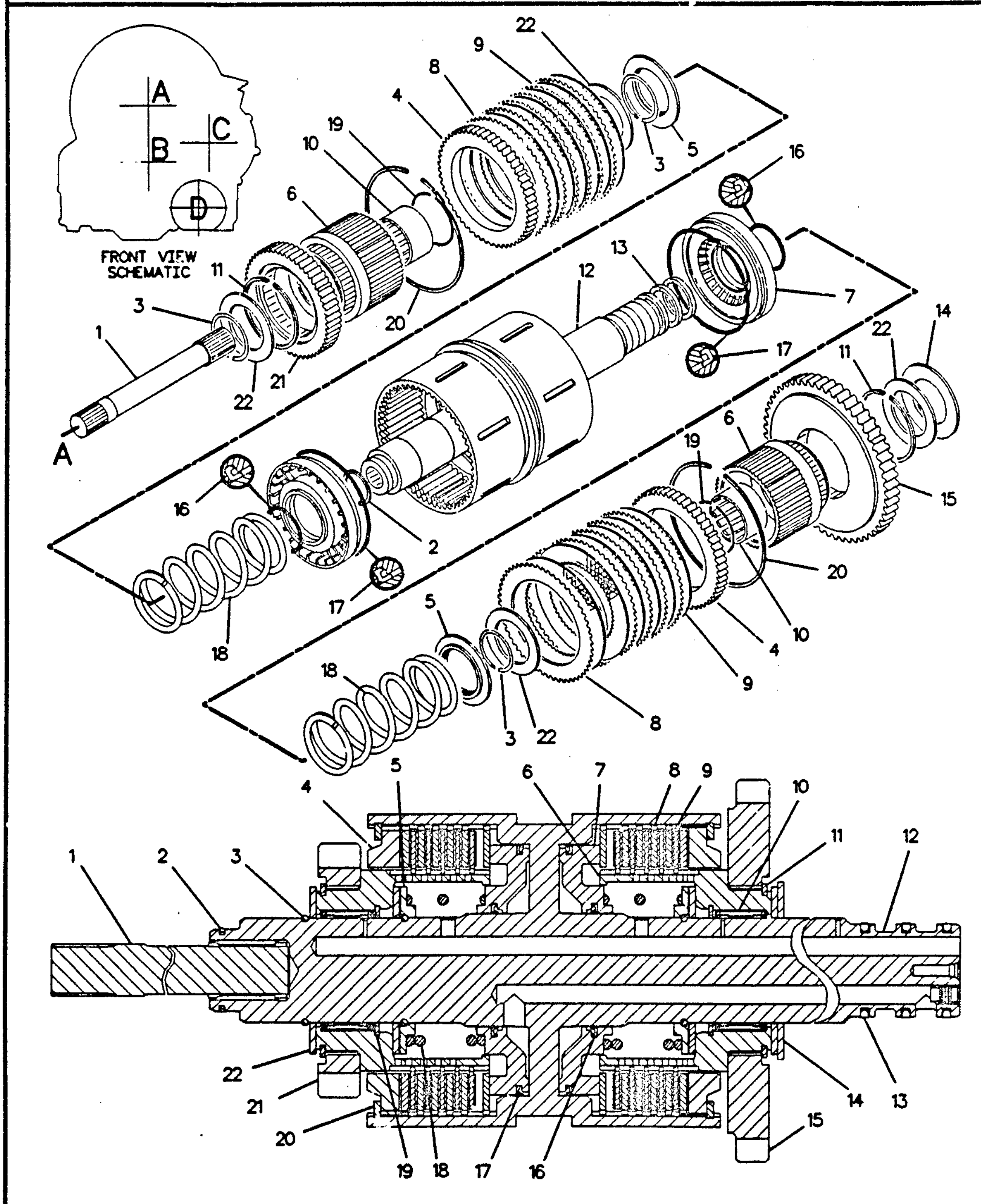
B-USE AS REQUIRED
D-ORDER BY THE METER
M-METRIC PART
Y-SEPARATE ILLUSTRATION

497610 EP

6Y5635 CASE & PARTS GP

9W7189-Page 90.

Part Of 6Y1617 Transmission Ar



3404 .

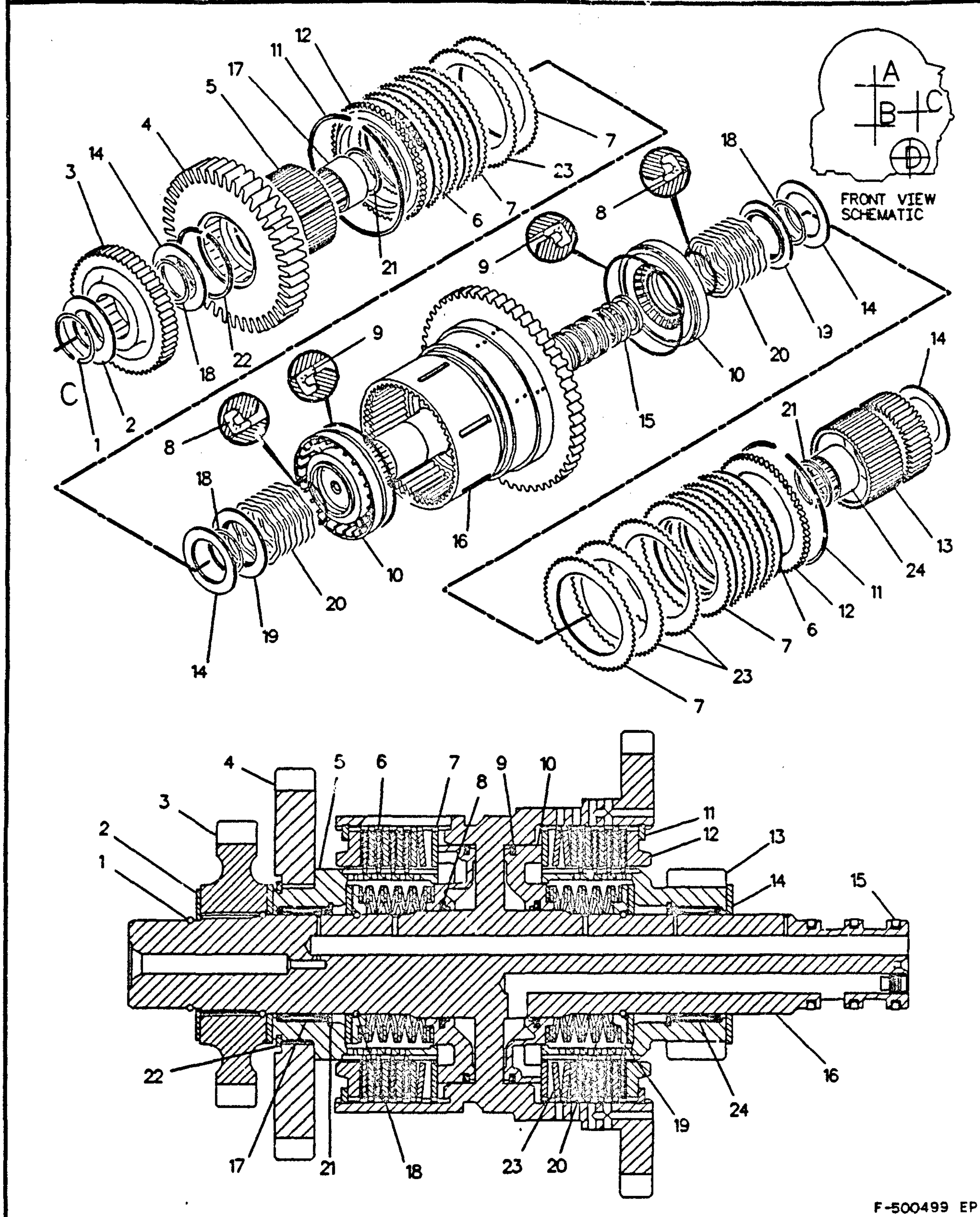
7T9400 CLUTCH GP
Forward & Reverse
Part Of 6Y1617 Transmission Ar

TRANSMISSION AND DRIVETRAIN

NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7T7085	1	SHAFT-CONVERTER					
	2	2L1784	1	RING-PISTON					
	3	9W6904	3	RING-RETAINER					
	4	6Y2799	2	PLATE-END					
	5	9W9718	2	RETAINER-SPRING					
	6	9W8013	2	HUB AS					
	7	6Y8157	2	PISTON					
C	8	6Y5631	12	PLATE					
	9	6Y7968	12	DISC-FRICTION					
	10	2W1141	2	BEARING					
	11	8C3979	2	RING-RETAINING					
	12	8E7170	1	SHAFT AS					
		9W0718	2	PLUG					
	13	6T6593	3	RING-SEAL					
	14	9W0827	1	WASHER-THRUST					
	15	9W8014	1	GEAR (46 TEETH)					
	16	9W9372	2	RING-SEAL					
	17	9W9371	2	RING-SEAL					
	18	6Y7818	2	SPRING					
	19	7X2495	2	RING-RETAINING					
	20	9X2309	2	RING-RETAINING					
	21	9W8007	1	GEAR (30 TEETH)					
	22	7T7341	4	DISC-THRUST					

508013 EP

7T9400 CLUTCH GP
Forward & Reverse
Part Of 6Y1617 Transmission Ar



7T9402 CLUTCH GP
1ST & 3RD
Part Of 6Y1617 Transmission Ar

TRANSMISSION AND DRIVETRAIN

NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9W6926	1	RING-RETAINER					
	2	9W0716	1	DISC-THRUST					
	3	9W8008	1	GEAR (36 TEETH)					
	4	9W6923	1	GEAR (50 TEETH)					
	5	9W8013	1	HUB AS					
	6	6Y7968	8	DISC-FRICTION					
C	7	6Y5631	10	PLATE					
	8	9W9372	2	RING-SEAL					
	9	9W9371	2	RING-SEAL					
	10	6Y8157	2	PISTON					
	11	9X2309	2	RING-RETAINING					
	12	6Y2799	2	PLATE-END					
	13	9N4655	2	GEAR					
	14	7T7341	4	DISC-THRUST					
	15	6T6593	3	RING-SEAL					
C	16	8E7172	1	SHAFT AS					
	17	2W1141	1	BEARING					
	18	9W6904	3	RING-RETAINER					
	19	9W9718	2	RETAINER-SPRING					
	20	6Y7618	2	SPRING					
	21	7X2495	2	RING-RETAINING					
	22	8C3979	1	RING-RETAINING					
	23	6Y6934	3	SPRING-DISC					
	24	9N4593	2	BEARING-ROLLER AS					

507221 EP

7T9402 CLUTCH GP
1ST & 3RD
Part Of 6Y1617 Transmission Ar

TRANSMISSION AND DRIVETRAIN

NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9W6926	1	RING-RETAINER					
	2	9W0716	1	DISC-THRUST					
	3	9W8008	1	GEAR (36 TEETH)					
	4	9W6923	1	GEAR (50 TEETH)					
	5	9W8013	1	HUB AS					
	6	6Y7968	8	DISC-FRICTION					
C	7	6Y5631	10	PLATE					
	8	9W9372	2	RING-SEAL					
	9	9W9371	2	RING-SEAL					
	10	6Y8157	2	PISTON					
	11	9X2309	2	RING-RETAINING					
	12	6Y2799	2	PLATE-END					
	13	9N4655	2	GEAR					
	14	7T7341	4	DISC-THRUST					
	15	6T6593	3	RING-SEAL					
C	16	8E7172	1	SHAFT AS					
	17	2W1141	1	BEARING					
	18	9W6904	3	RING-RETAINER					
	19	9W9718	2	RETAINER-SPRING					
	20	6Y7818	2	SPRING					
	21	7X2495	2	RING-RETAINING					
	22	8C3979	1	RING-RETAINING					
	23	6Y6934	3	SPRING-DISC					
	24	9N4593	2	BEARING-ROLLER AS					

507221 EP

7T9402 CLUTCH GP
1ST & 3RD
Part Of 6Y1617 Transmission Ar

TRANSMISSION AND DRIVETRAIN

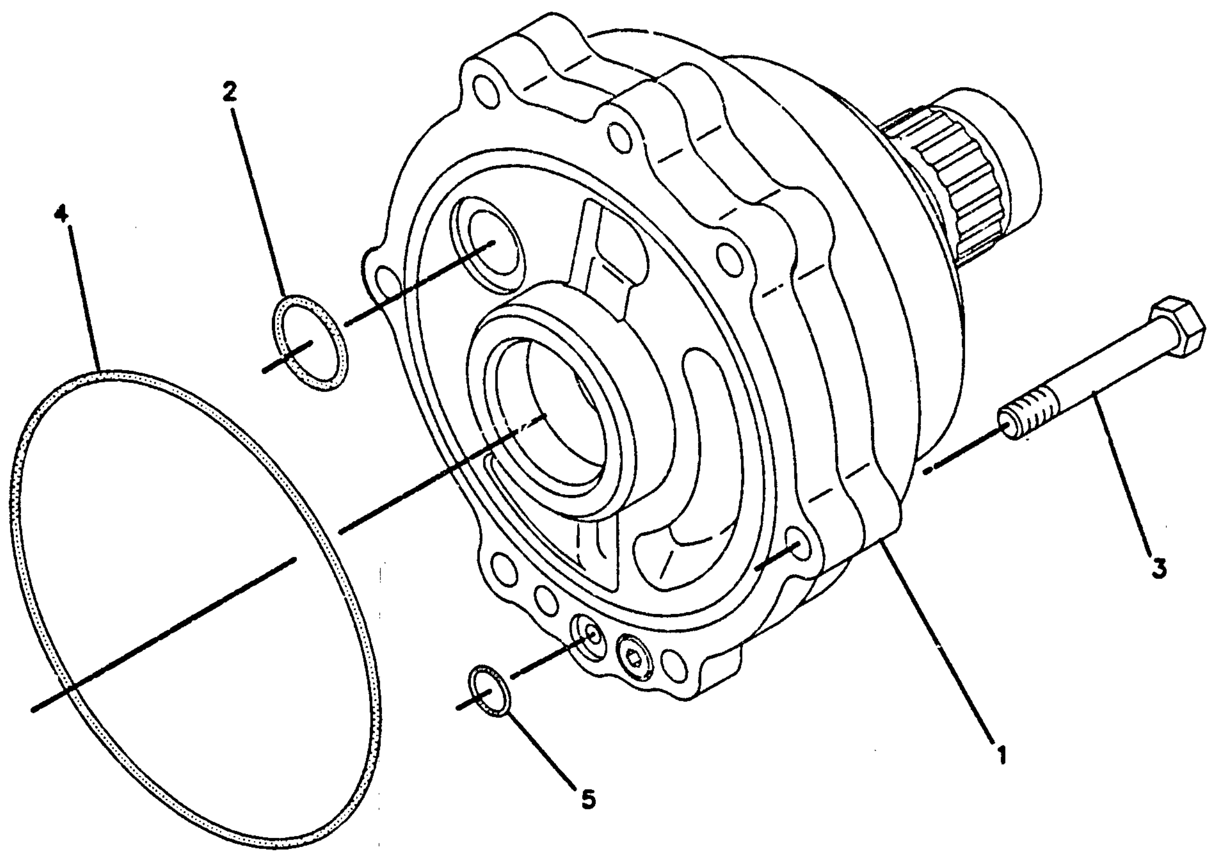
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6T6593	3	RING-SEAL					
	2	7J8210	1	CONE-ROLLER BEARING					
	3	7T7347	1	WASHER-THRUST					
	4	7T7341	2	DISC-THRUST					
	5	9W8027	1	GEAR (60 TEETH)					
	6	9X2309	2	RING-RETAINING					
	7	6Y2799	2	PLATE-END					
	8	6Y7818	2	SPRING					
	9	9W9371	2	RING-SEAL					
	10	9W9372	2	RING-SEAL					
	11	9W9718	2	RETAINER-SPRING					
	12	1P2662	1	CONE-ROLLER BEARING					
	13	8E7171	1	SHAFT AS					
	14	8E3154	1	GEAR (92 TEETH)					
	15	9W8056	1	GEAR (36 TEETH)					
	16	6Y7968	10	DISC-FRICTION					
	17	6Y5631	5	PLATE					
	18	6Y8157	2	PISTON					
	19	9W6904	2	RING-RETAINER					
	20	7X2495	2	RING-RETAINING					
	21	9W8013	1	HUB AS					
	22	8C3379	2	RING-RETAINING					
	23	2W1141	2	BEARING					
	24	6Y6934	2	SPRING-DISC					
	25	9W8037	1	DISC-THRUST					
	26	9W9340	1	DISC-THRUST					
	27	6Y6952	1	HUB AS					
	28	8E1459	7	PLATE					

507217 EP

3404

7T9401 CLUTCH GP
2ND & 4TH
Part Of 6Y1617 Transmission Ar

TRANSMISSION AND DRIVETRAIN

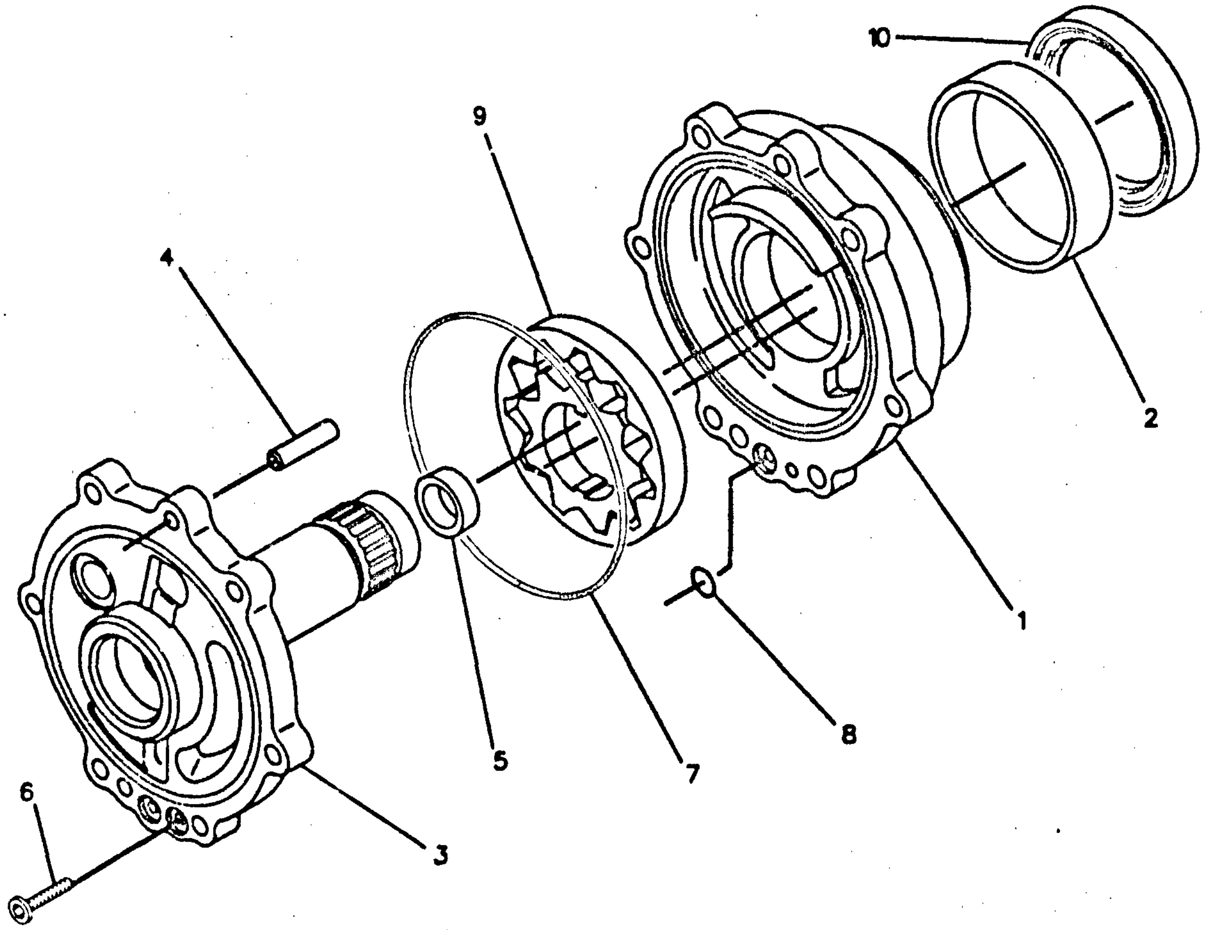


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	8E8658	1	PUMP GP-CRESCENT					
	2	5P6718	1	SEAL-O-RING					
M	3	8T0100	6	BOLT					
	4	6V8260	1	SEAL-O-RING					
	5	6V4366	1	SEAL-O-RING					

M-METRIC PART
Y-SEPARATE ILLUSTRATION

F-512772 EP

8E8657 PUMP GP-CRESCENT
8E8658-Page 89
Part Of 6Y1617 Transmission Ar

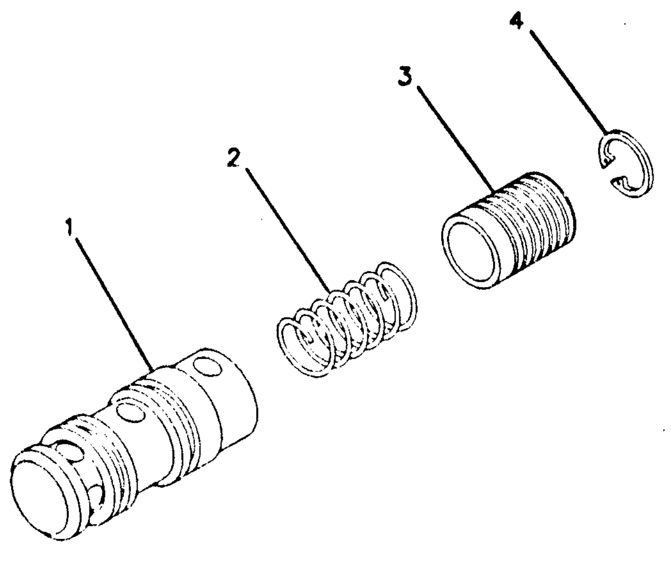


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6Y6713	1	HOUSING AS-PUMP
	2	6Y6716	1	BEARING-SLEEVE
	3	6Y6715	1	SUPPORT AS
	4	6V8760	2	DOWEL
	5	7T7344	1	BEARING
M	6	6V5683	1	BOLT
	7	6V8260	1	SEAL-O-RING
	8	6V4366	1	SEAL-O-RING
	9	8E8763	1	GEAR AS-CRESCENT
	10	8C5188	1	SEAL-LIP TYPE

M-METRIC PART

F-512774 EP

8E8658 PUMP GP-CRESCENT
Part Of 8E8657 Pump-Crescent



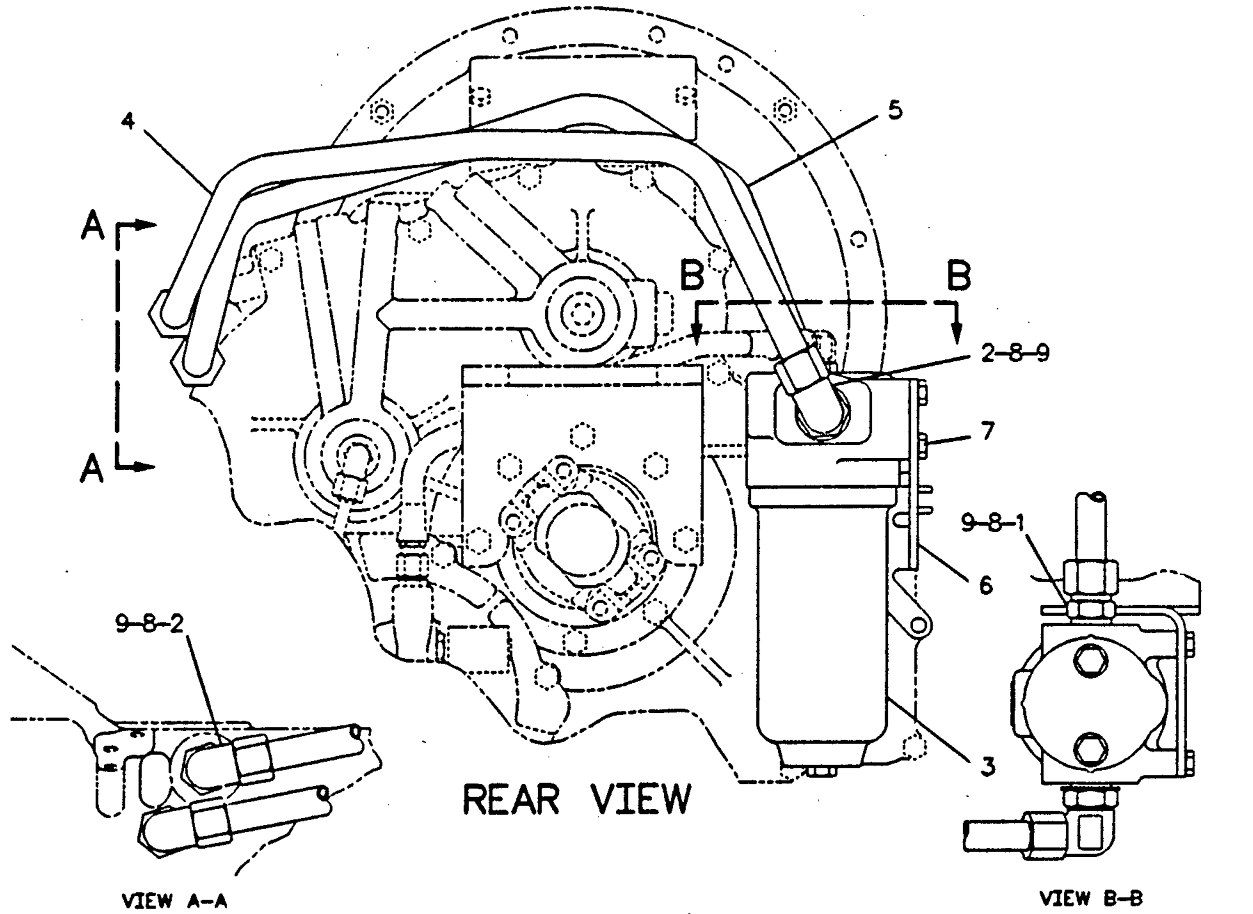
NOTE	REF NO	PART NUMBER	QTY	PART NAME
Z	1		1	(BODY)
	2	4M7945	1	SPRING
	3	9W0884	1	PISTON
	4	2L6726	1	RING-RETAINING

Z-NOT SERVICED SEPARATELY

F-462663 EP

9W7183 VALVE GP-FLOW CONTROL
Part Of 6Y5635 Case & Parts

TRANSMISSION AND DRIVETRAIN



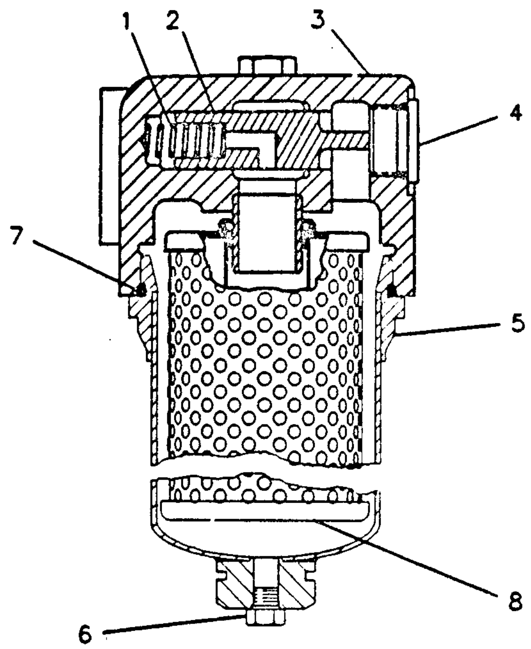
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6V8637	1	CONNECTOR-SEAL					
	2	6V9007	3	ELBOW					
Y	3	6Y3560	1	FILTER GP-TRANSMISSION					
	4	6Y4467	1	TUBE AS-FILTER					
	5	6Y1247	1	TUBE AS-SUPPLY					
	6	8E0295	1	BRACKET-FILTER					
M	7	6V6317	4	BOLT					
	8	6V9746	4	SEAL-O-RING (19.79MM ID)					
	9	3D2824	4	SEAL-O-RING (23.47MM ID)					

M-METRIC PART
Y-SEPARATE ILLUSTRATION

F-497605 EP

6Y5641 LINES GP-POWER TRAIN OIL
6Y3560-Page 92.

TRANSMISSION AND DRIVETRAIN

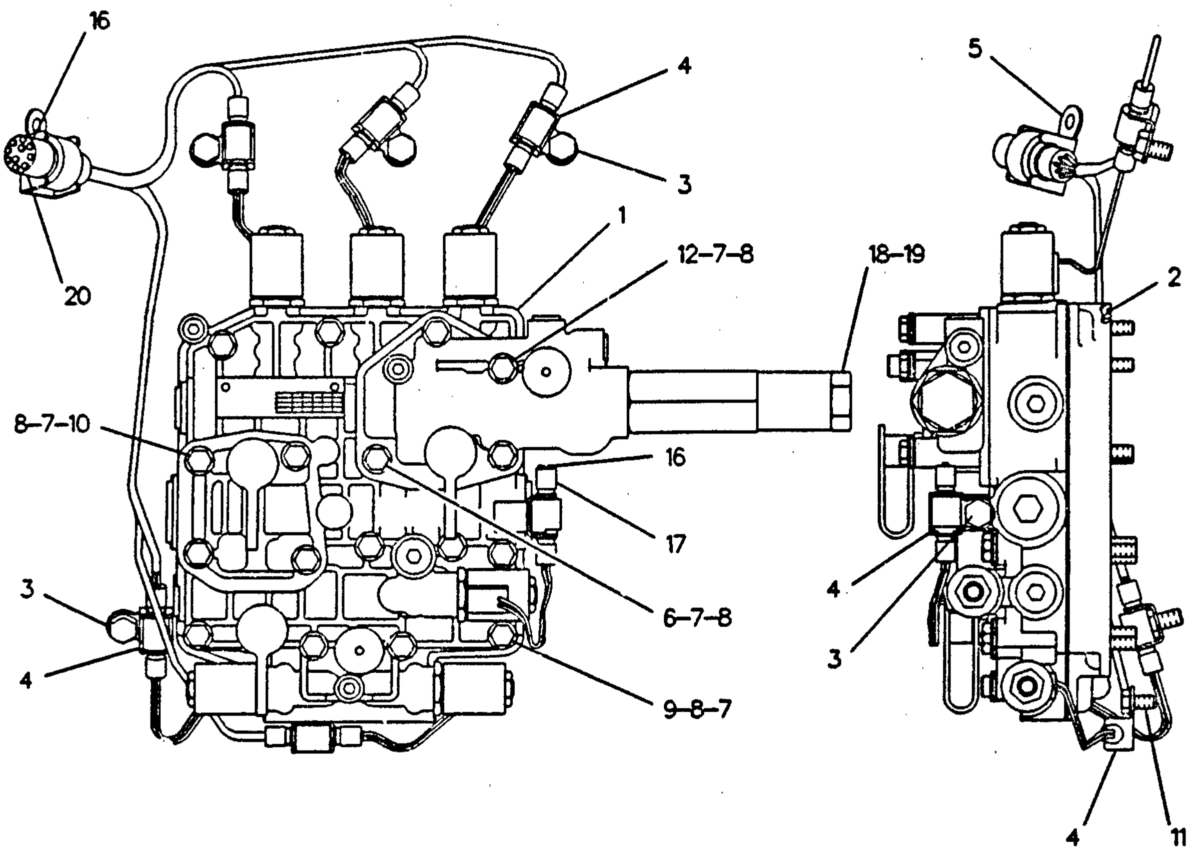


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9M1986	1	SPRING
	2	9P1508	1	SPOOL
	3	6Y3561	1	BASE AS-TRANSMISSION
	4	9S8008	1	PLUG-O-RING
		3D2824	1	SEAL-O-RING (23.47MM ID)
	5	8E0762	1	HOUSING AS
	6	9S4191	3	PLUG-O-RING (9/16 X 18 THD)
		3J1907	3	SEAL-O-RING (11.89MM ID)
	7	8H7521	1	SEAL-O-RING
	8	9T9054	1	ELEMENT-FILTER

R-503208 EP

3402

6Y3560 FILTER GP-TRANSMISSION (WITH HOUSING)
Part Of 6Y5641 Lines-Power Train Oil



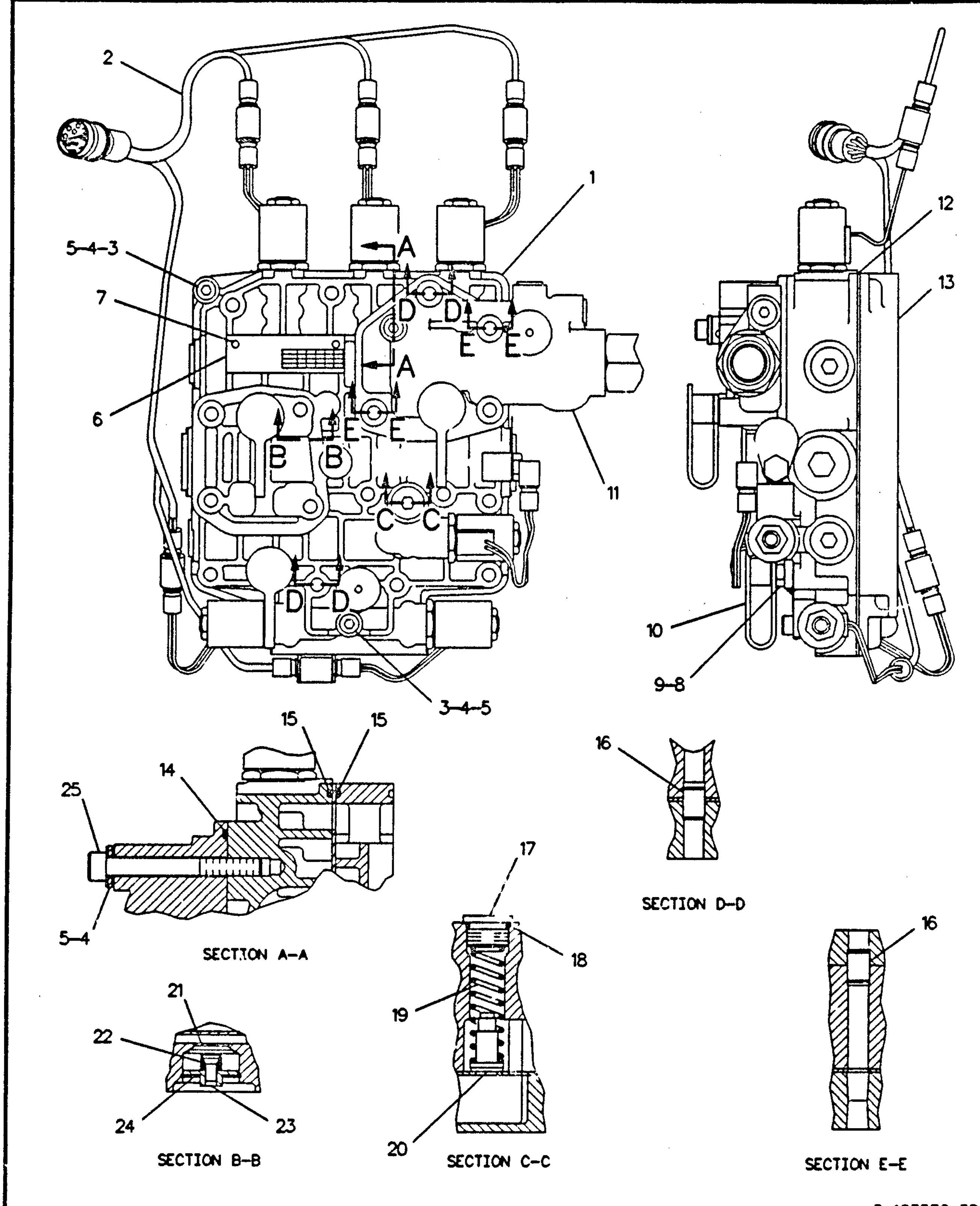
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	6Y1292	1	VALVE GP					
	2	8C5175	1	SEAL-O-RING					
M	3	6V8212	6	BOLT					
	4	9G9150	6	CLIP					
	5	3T0050	1	CLIP					
M	6	6V3821	1	BOLT					
	7	9P9150	34	WASHER					
	8	1T0738	17	WASHER					
M	9	8T0292	9	BOLT					
M	10	6V5223	4	BOLT					
M	11	6V5215	1	BOLT					
M	12	7X0870	3	BOLT					

M-METRIC PART
Y-SEPARATE ILLUSTRATION

F-497572 EP

6Y1293 CONTROL GP-TRANSMISSION HYDRAULIC

6Y1292-Page 94



3418

6Y1292 VALVE GP
Part Of 6Y1293 Control-Transmission Hydraulic

NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	6Y1291	1	VALVE GP-SELECTOR & PRESS CONT					
	2	6Y2167	1	HARNESS AS					
M	3	8T9535	2	BOLT-SOCKET HEAD					
	4	1T0738	3	WASHER					
	5	9P9150	6	WASHER					
	6	6Y2541	1	PLATE-SOLENOID CHART					
	7	7B3028	2	SCREW-DRIVE					
	8	6V3965	2	NIPPLE AS					
	9	3J1907	2	SEAL-O-RING					
	10	6V0852	2	CAP-DUST					
Y	11	6Y1290	1	VALVE GP-CONTROL					
	12	6Y6016	1	PLATE					
	13	6Y5816	1	MANIFOLD					
	14	3K0715	1	SEAL-O-RING					
	15	8C5176	2	SEAL-O-RING					
	16	9L9068	4	DOWEL					
	17	9S8005	1	PLUG-O-RING					
	18	3K0360	1	SEAL-O-RING					
	19	6Y2571	1	SPRING					
	20	7T8810	1	PLUNGER					
	21	6Y4978	1	POPPET					
	22	3J6956	1	SPRING					
	23	6Y2584	1	RETAINER					
	24	4D1322	1	RING-RETAINING					
M	25	6V8213	1	BOLT-SOCKET HEAD					

M-METRIC PART
Y-SEPARATE ILLUSTRATION

497577 EP

3418

6Y1292 VALVE GP

6Y1290-Page 96. 6Y1291-Page 97.

Part Of 6Y1293 Control-Transmission Hydraulic

TRANSMISSION AND DRIVETRAIN

NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	6Y1291	1	VALVE GP-SELECTOR & PRESS CONT					
	2	6Y2167	1	HARNESS AS					
M	3	8T9535	2	BOLT-SOCKET HEAD					
	4	1T0738	3	WASHER					
	5	9P9150	6	WASHER					
	6	6Y2541	1	PLATE-SOLENOID CHART					
	7	7B3028	2	SCREW-DRIVE					
	8	6V3965	2	NIPPLE AS					
	9	3J1907	2	SEAL-O-RING					
	10	6V0852	2	CAP-DUST					
Y	11	6Y1290	1	VALVE GP-CONTROL					
	12	6Y6016	1	PLATE					
	13	6Y5816	1	MANIFOLD					
	14	3K0715	1	SEAL-O-RING					
	15	8C5176	2	SEAL-O-RING					
	16	9L9068	4	DOWEL					
	17	9S8005	1	PLUG-O-RING					
	18	3K0360	1	SEAL-O-RING					
	19	6Y2571	1	SPRING					
	20	7T8810	1	PLUNGER					
	21	6Y4978	1	POPPET					
	22	3J6956	1	SPRING					
	23	6Y2584	1	RETAINER					
	24	4D1322	1	RING-RETAINING					
M	25	6V8213	1	BOLT-SOCKET HEAD					

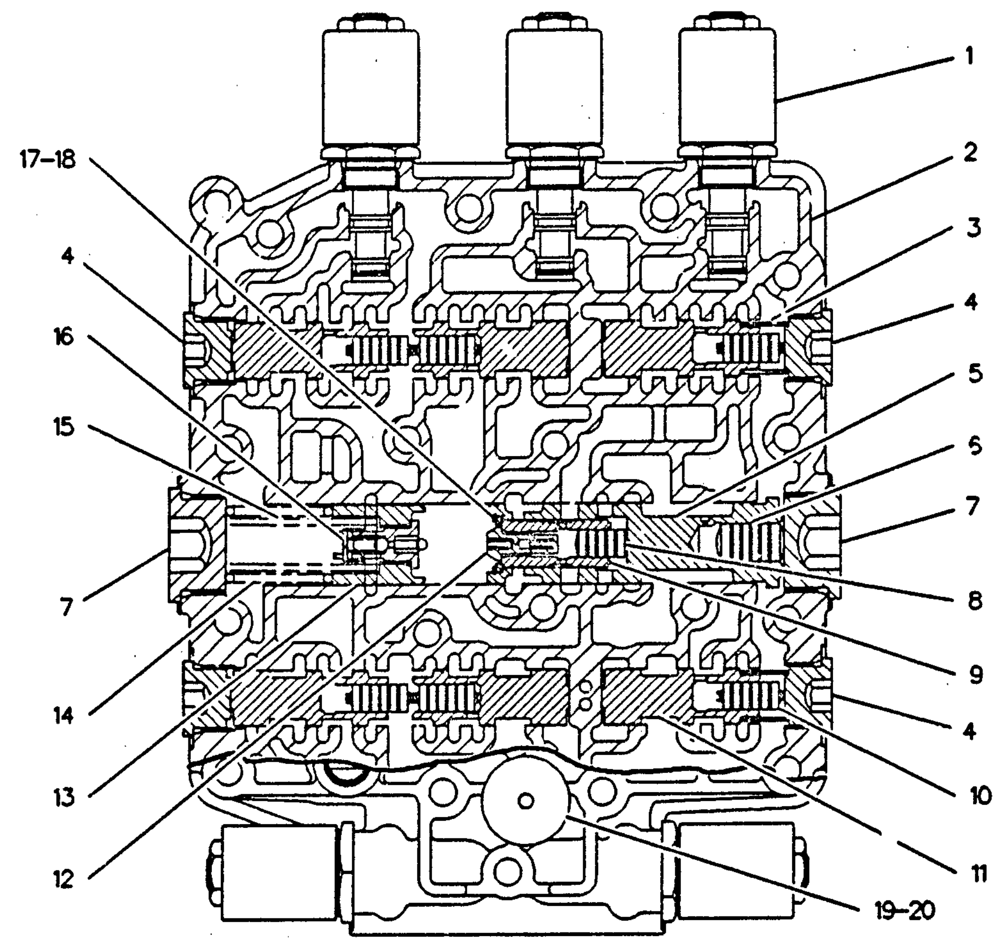
M-METRIC PART
Y-SEPARATE ILLUSTRATION

497577 EP

6Y1292 VALVE GP

6Y1290-Page 96. 6Y1291-Page 97.

Part Of 6Y1293 Control-Transmission Hydraulic



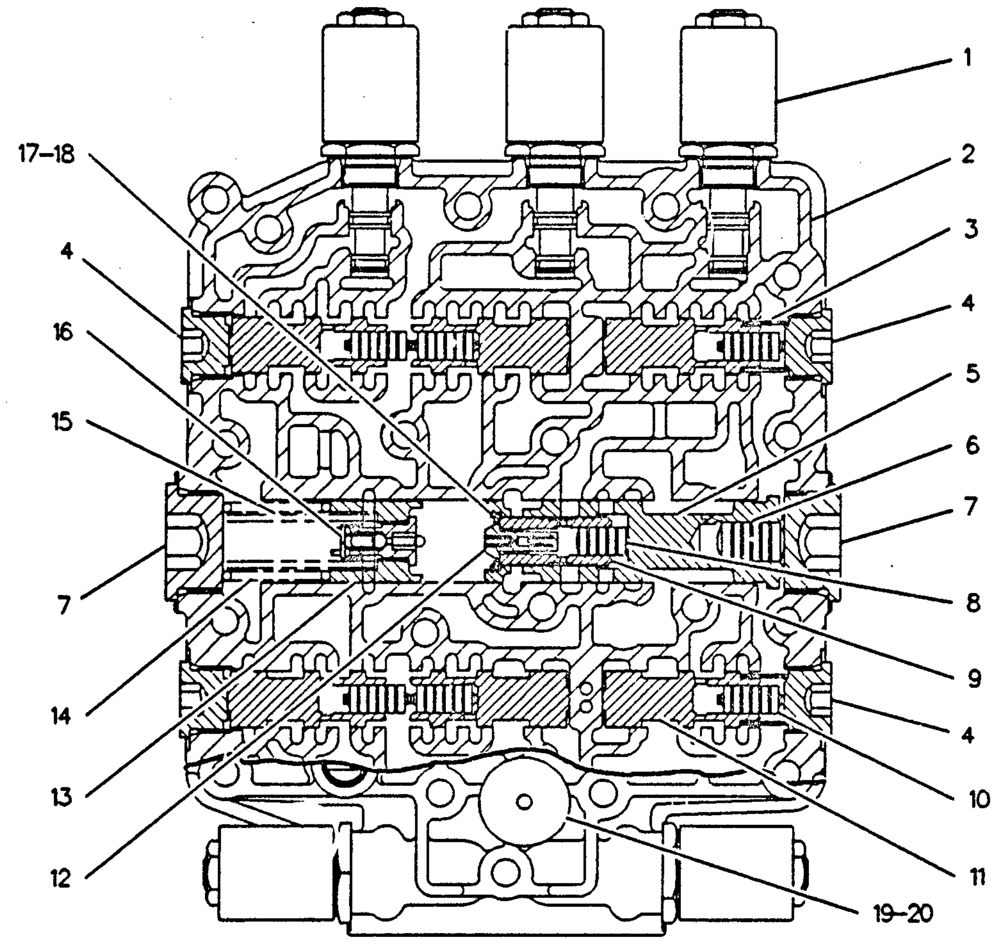
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9W2740	6	VALVE GP-SOLENOID		11	9W6097	6	SPOOL-SELECTOR
				(EACH INCLUDES)		12	7T8803	1	PLUG-SCREEN
		9W2180	1	VALVE GP-SOLENOID		13	9W8279	1	PISTON
				(AUTOMATIC SW CO)		14	6Y7620	1	SPRING
				-OR-		15	8E1139	1	SPRING
		7T4512	1	VALVE GP-SOLENOID		16	9W7423	1	VALVE AS-RELIEF
				(FLUID POWER SYS)			5B9318	1	BALL
		7X6282	1	CARTRIDGE AS		17	8J2283	1	RING-SNAP
		0L1013	1	NUT		18	7T8797	1	SPACER
		7T4515	1	KIT-SEAL		19	8E2802	1	PLATE-IDENTIFICATION
		8C5575	1	COIL AS-12VDC		20	7B3028	1	SCREW-DRIVE
		7N9737	1	HOUSING-PLUG					
		7N7780	1	PIN-CONNECTOR					
		7N7779	1	SOCKET					
		1S9593	2	STRAP-CABLE					
	2	6Y2256	1	BODY					
	3	6Y0871	2	SPRING					
	4	7T7679	4	PLUG-STR THREAD					
		2M9780	4	SEAL-O-RING					
	5	8E3674	1	SPOOL					
	6	8E1143	1	SLUG					
	7	6Y4638	2	PLUG-HEX SOCKET					
		7M8485	2	SEAL-O-RING					
	8	8E1142	1	SLUG					
	9	8E3675	1	SPOOL					
	10	9W6096	6	SLUG					

F-497578 EP

6Y1291 VALVE GP-SELECTOR & PRESSURE CONTROL

Type 1

Part Of 6Y1292 Valve-Test

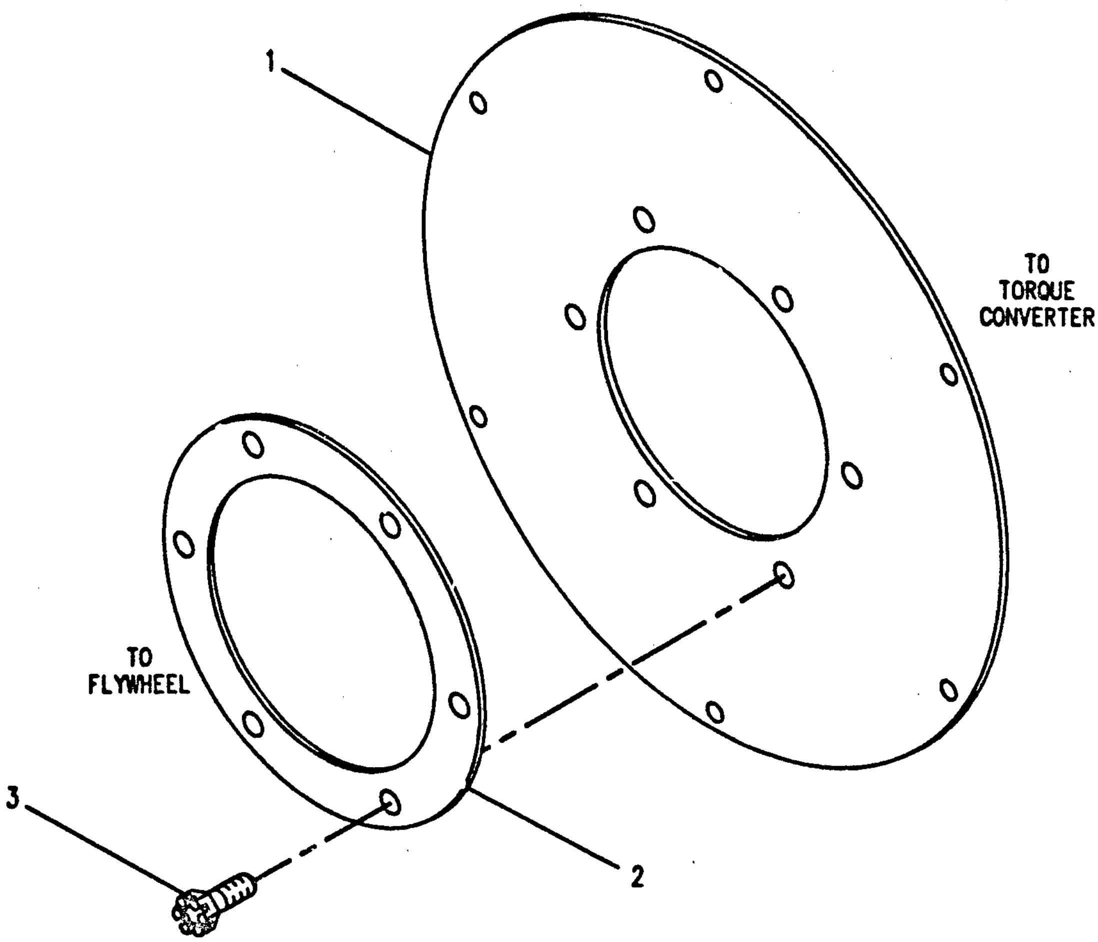


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3E6268	6	VALVE GP-SOLENOID		16	9W7423	1	VALVE AS-RELIEF
				(EACH INCLUDES)			5B9318	1	BALL
		3E6267	1	CARTRIDGE AS		17	8J2283	1	RING-SNAP
		0L1013	1	NUT		18	7T8797	1	SPACER
		7T4512	1	VALVE GP-SOLENOID		19	8E2802	1	PLATE-IDENTIFICATION
		8C5575	1	COIL AS-12VDC		20	7B3028	1	SCREW-DRIVE
		7N9737	1	HOUSING-PLUG					
		7N7780	1	PIN-CONNECTOR					
		7N7779	1	SOCKET					
		1S9593	2	STRAP-CABLE					
	2	6Y2256	1	BODY					
	3	6Y0871	2	SPRING					
	4	7T7679	4	PLUG-STR THREAD					
		2M9780	4	SEAL-O-RING					
	5	8E3674	1	SPOOL					
	6	8E1143	1	SLUG					
	7	6Y4638	2	PLUG-HEX SOCKET					
		7M8485	2	SEAL-O-RING					
	8	8E1142	1	SLUG					
	9	8E3675	1	SPOOL					
	10	9W6096	6	SLUG					
	11	9W6097	6	SPOOL-SELECTOR					
	12	7T8803	1	PLUG-SCREEN					
	13	9W8279	1	PISTON					
	14	6Y7620	1	SPRING					
	15	8E1139	1	SPRING					

F-513004 EP

6Y1291 VALVE GP-SELECTOR & PRESSURE CONTROL
Type 2
Part Of 6Y1292 Valve-Test

MEMORANDA

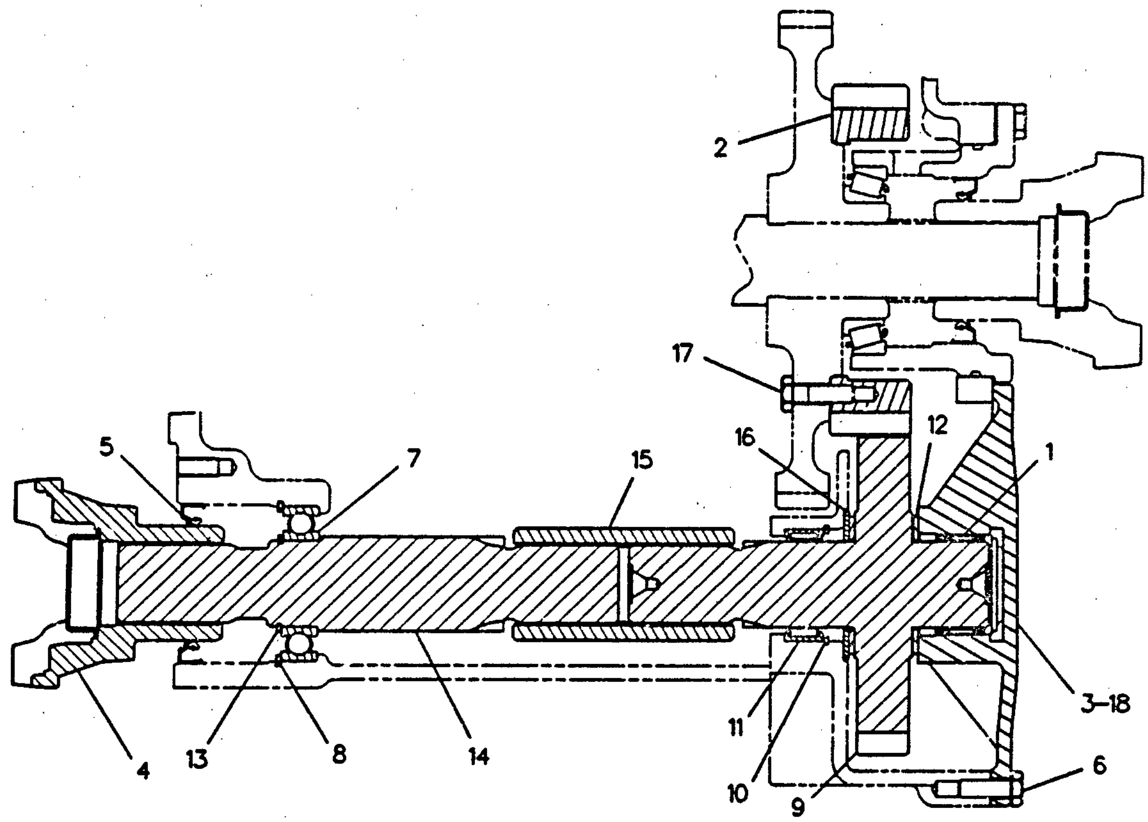


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7T2742	1	PLATE-CONVERTER DRIVE					
	2	6T9487	1	PLATE					
	3	0L1138	6	BOLT					

F-497642 EP

3252

9W8214 DRIVE GP-FLEXIBLE COUPLING
Part Of 6Y1617 Transmission Ar

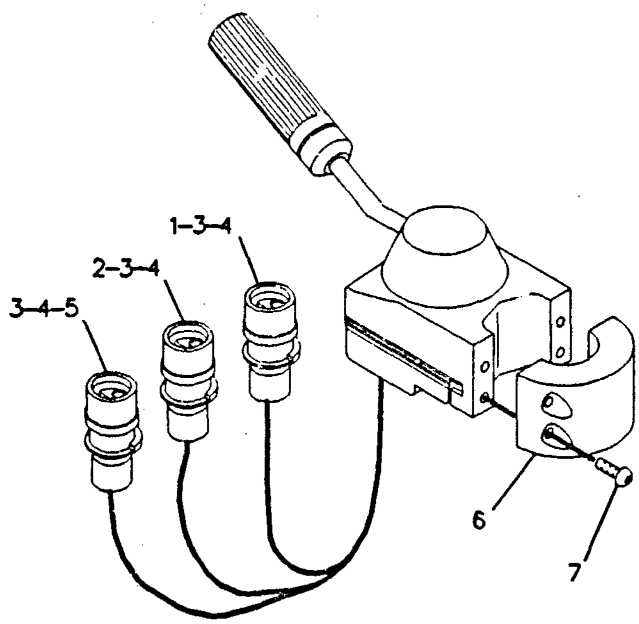


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2W1141	1	BEARING
	2	7T9732	1	GEAR
	3	6Y8152	1	CAGE-BEARING
	4	9R4314	1	YOKE AS
	5	7K2830	1	SEAL-LIP TYPE
M	6	6V1820	6	BOLT
	7	1T0043	1	BALL BEARING
	8	8C3229	1	RING-RETAINING
	9	6Y8153	1	GEAR-OUTPUT
	10	8C6897	1	RING-RETAINING
	11	9W1475	1	BEARING-ROLLER
	12	7T7341	2	DISC-THRUST
	13	1T0205	1	RING-SNAP
	14	6Y3841	1	SHAFT
	15	9W1449	1	COUPLING
	16	9W0827	1	WASHER-THRUST
M	17	6V3822	12	BOLT
BD	18	8C8422		SEALANT

B-USE AS REQUIRED
D-ORDER BY THE METER
M-METRIC PART

F-497623 EP

6Y8151 DRIVE GP-TRANSFER
Part Of 6Y1617 Transmission Ar



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9G3668	1	HOUSING-PLUG					
	2	9G3671	1	HOUSING-PLUG					
	3	7N7779	10	SOCKET					
	4	7N7780	11	PIN-CONNECTOR					
	5	9G3677	1	HOUSING-RECEPTACLE					
	6	7X6325	1	CLAMP-COLUMN					
M	7	9X6615	4	BOLT-HEX HEAD					

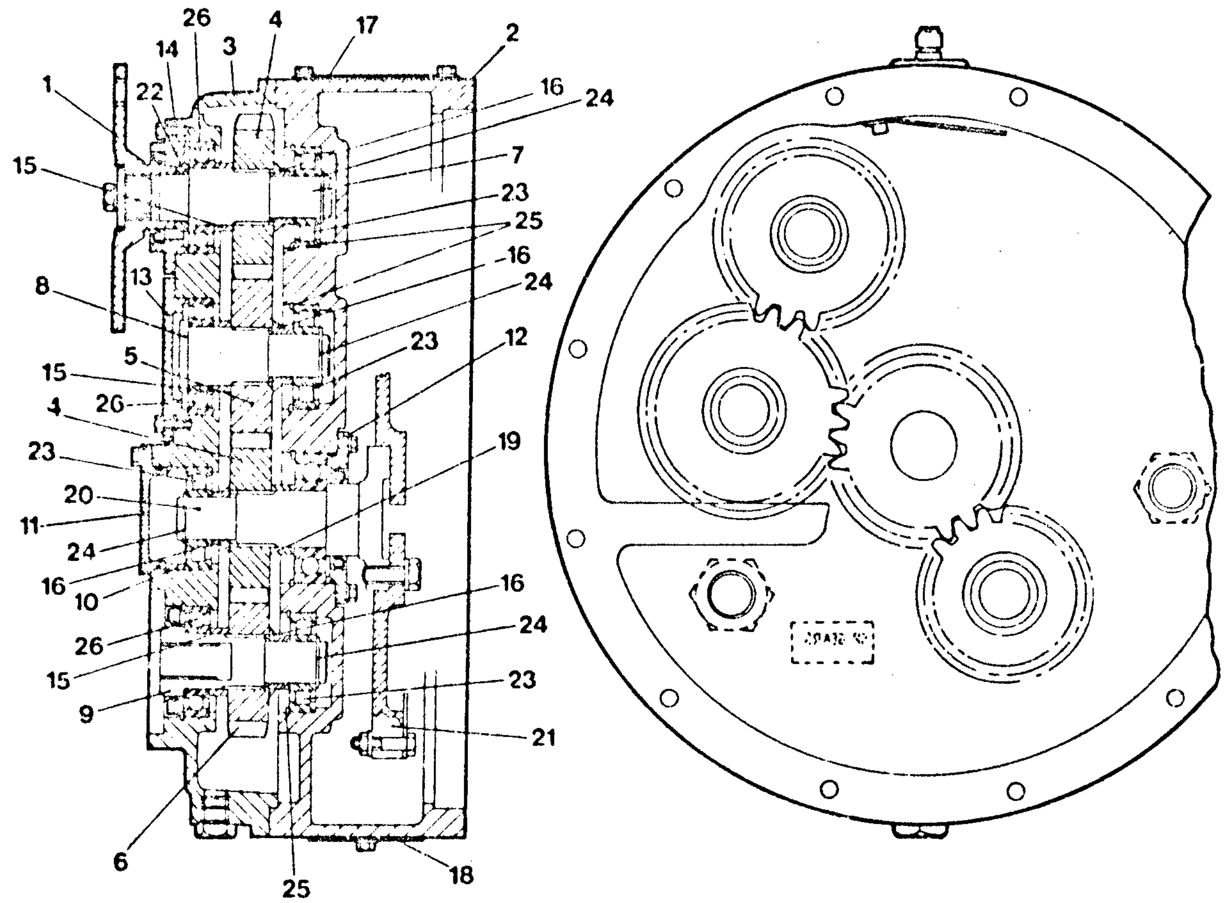
M-METRIC PART

F-513050 EP

3E3499 CONTROL GP-TRANSMISSION
Part of 6R1918 Electrical Group - Steering Column

MEMORANDA

TRANSMISSION AND DRIVETRAIN

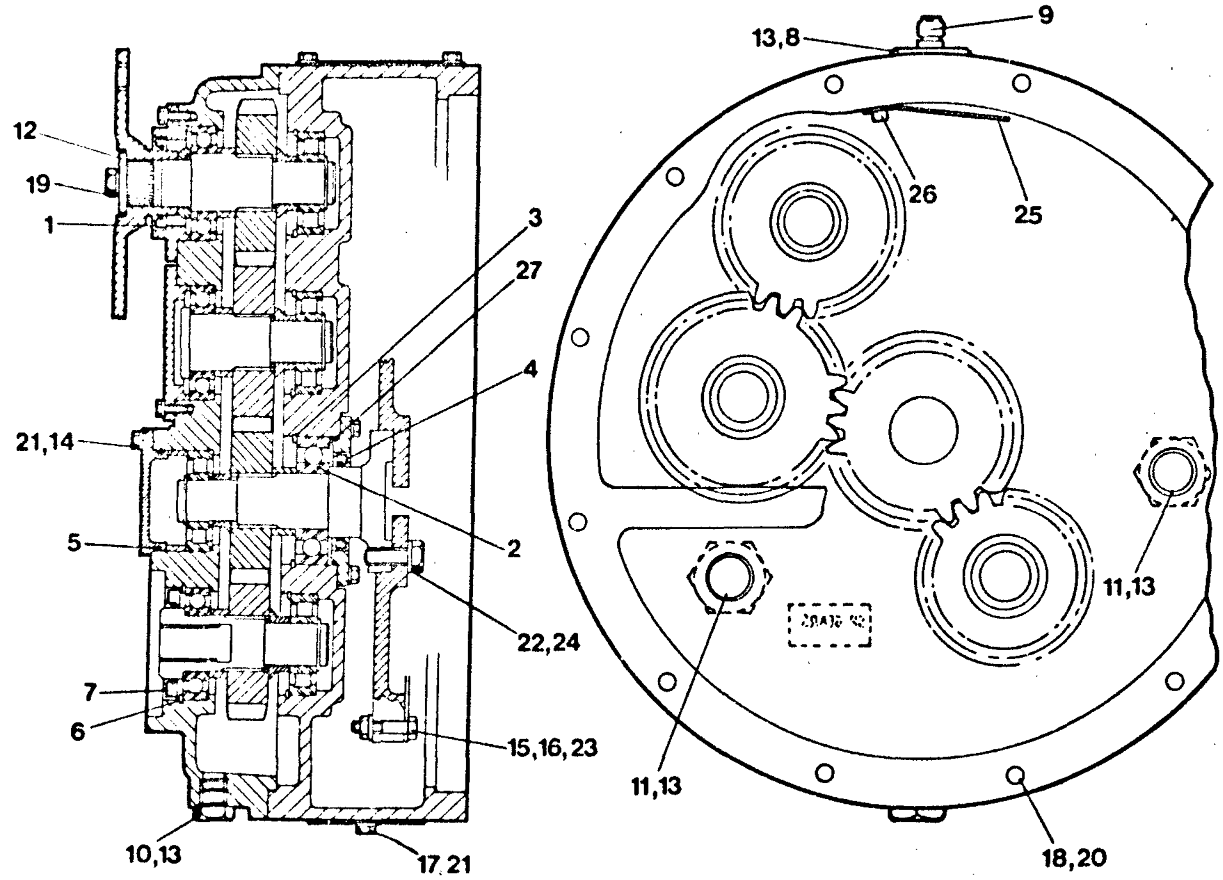


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815690	1	INPUT FLANGE		14	898253	1	SEAL CARRIER
	2	898144	1	CASING		15	8Q2112	3	SPACER
	3	898145	1	CASING		16	8Q2110	4	SPACER
	4	8Q2108	2	GEAR - 21 TEETH		17	898256	1	TOP COVER
	5	8Q2109	1	GEAR - 23 TEETH		18	898257	1	BOTTOM COVER
	6	8Q2107	1	GEAR - 19 TEETH		19	8Q2111	1	SPACER
	7	898238	1	INPUT SHAFT		20	898278	1	OUTPUT SHAFT
	8	898239	1	IDLER SHAFT		21	898279	1	OUTPUT FLANGE
	9	898241	1	PUMP DRIVE SHAFT		22	898280	1	SPACER
	10	898249	1	SPACER		23	6R8966	4	BEARING
	11	898250	1	END COVER		24	6R8967	4	CIRCLIP EXTERNAL
	12	8Q2089	1	SEAL CARRIER		25	6R8968	3	CIRCLIP INTERNAL
	13	898252	1	END COVER		26	6H3957	3	BEARING-DEEP GROOVE BALL

P8Q2699 Y
REV 000

8Q2699 GEARBOX GROUP (1 of 2)
Part of 837968 Transmission Group

TRANSMISSION AND DRIVETRAIN



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
J	1	6R8970	1	SEAL	M	14	5C9553	23	BOLT
	2	2H3712	1	BEARING	M	15	6V9189	6	NYLOC NUT
	3	6R8972	1	CIRCLIP - INTERNAL	M	16	7X2537	6	BOLT
J	4	6R8973	1	SEAL	M	17	7X2619	6	BOLT
J	5	6R8974	1	O. RING	M	18	8T4121	23	WASHER
	6	6R8975	1	CIRCLIP - INTERNAL	M	19	8T4137	1	BOLT
J	7	6R8976	1	SEAL	M	20	8T4195	23	BOLT
	8	8[illegible]114	1	PLUG	M	21	8T4205	29	WASHER
	9	6[illegible]700	1	BREATHER PLUG	M	22	5P8245	6	WASHER
	10	816129	1	MAGNETIC PLUG	M	23	8T4224	6	WASHER
	11	9S4183	2	PLUG	M	24	6V3668	6	BOLT
	12	2B6010	1	WASHER		25	6R9267	1	DEFLECTOR PLATE
J	13	3D2824	4	O. RING		26	7J0637	2	SCREW
					J	27	8Q2075	1	O. RING

M - METRIC PART

J - PARTS INCLUDED IN SEAL KIT 510607

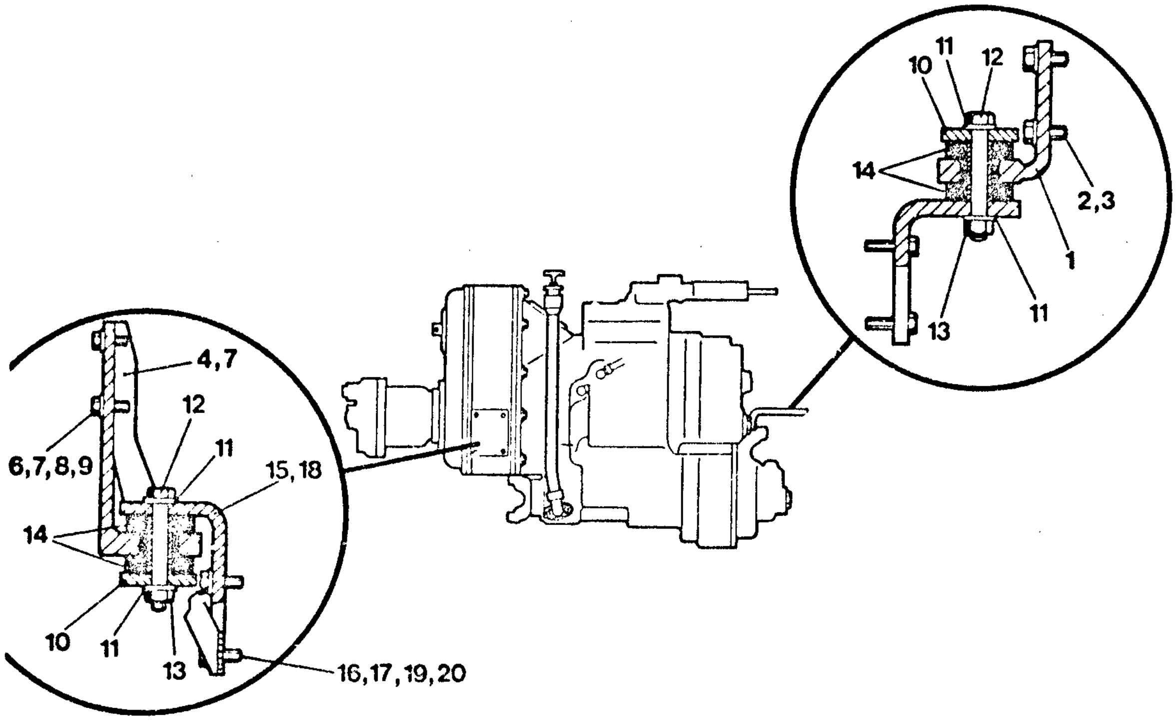
P8Q2699 Y

REV 000

8Q2699 GEARBOX GROUP (2 of 2)

Part of 837968 Transmission Group

TRANSMISSION AND DRIVETRAIN



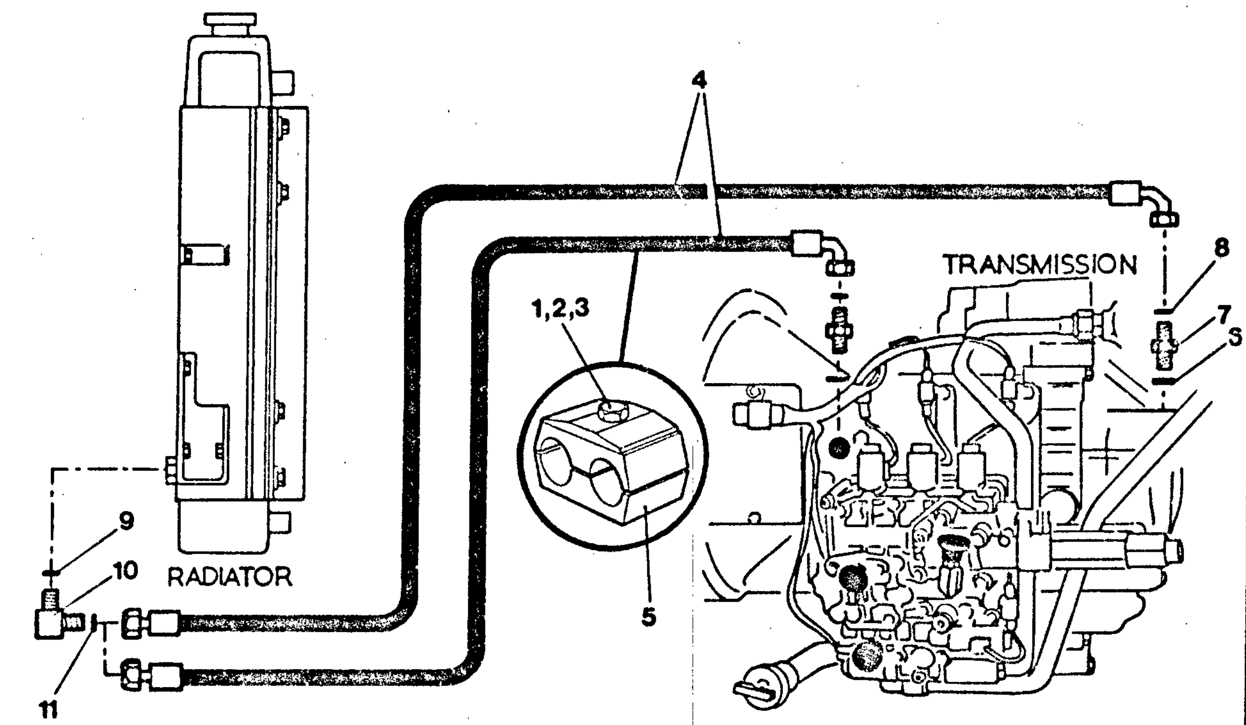
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815448	1	BRCKET-TRANSMISSION MOUNTING	M	11	4D3704	6	WASHER
M	2	8T4139	4	BOLT	M	12	8T0282	3	BOLT
M	3	8T4223	4	WASHER	M	13	8T1757	3	NUT
	4	838052	1	BRACKET AS. L.H.		14	9R0390	3	MOUNTING AS.
M	5	8T4139	4	BOLT		15	815451	1	BRCKET AS.-TRANSMISSION R.H.
M	6	8T4223	4	WASHER	M	16	8T4139	4	BOLT
	7	838048	1	BRACKET AS. R.H.	M	17	8T4223	4	WASHER
M	8	8T4139	4	BOLT		18	815452	1	BRCKET AS.-TRANSMISSION L.H
M	9	8T4223	4	WASHER	M	19	8T4139	4	BOLT
	10	3T6742	3	RETAINER	M	20	8T4223	4	WASHER

M - METRIC PART

P838068 Y
REV 000

838068 MOUNTING GROUP (TRANSMISSION)
Part of 817968 Transmission Group

TRANSMISSION AND DRIVETRAIN



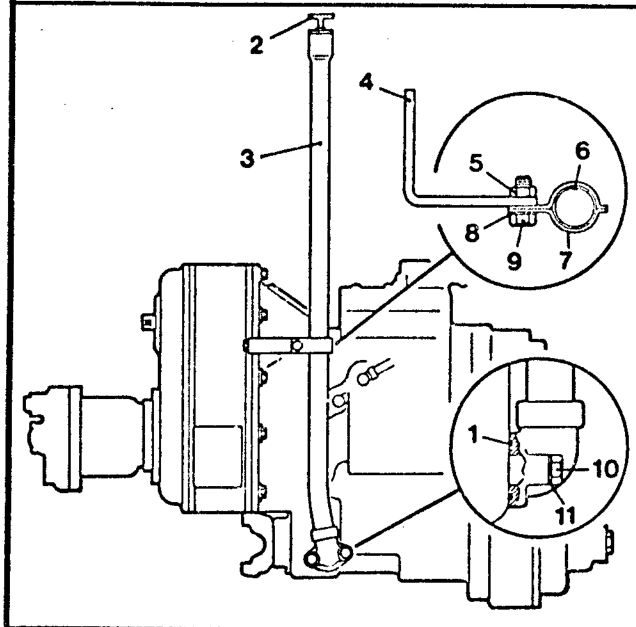
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V9189	4	NYLOC NUT		7	6V9007	2	ADAPTOR
M	2	8T4224	4	WASHER		8	6V9746	2	O RING (O.R.F.S.)
M	3	8T6870	4	BOLT		9	3D2824	2	O RING (O.R.B.)
	4	838448	2	HOSE AS.		10	6V8637	2	ADAPTOR
	5	838449	4	PIPE CLAMP AS.		11	6V9746	2	O RING (O.R.F.S.)
	6	3D2824	2	O RING (O.R.B.)					

M - METRIC PART

P838450 Y
REV 000

838450 TRANSMISSION PIPING GROUP
Part of 817968 Transmission Group

TRANSMISSION AND DRIVETRAIN



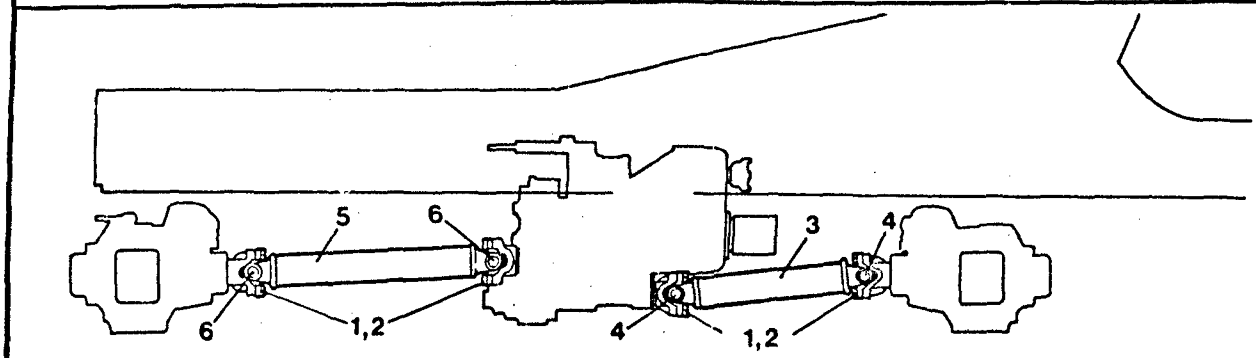
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	4J0522	1	O-RING
	2	6R8932	1	GAUGE AS
	3	6R9001	1	TUBE AS
	4	6R9027	1	SUPPORT STRAP
	5	6V7744	1	NUT
	6	8S0023	1	CLIP(SLOT)
	7	8S0024	1	CLIP(TAB)
M	8	8T4121	1	WASHER
M	9	8T4136	1	BOLT
M	10	8T4194	2	BOLT
M	11	8T4223	2	WASHER

M - METRIC PART

P6R8934 Y
REV 000

6R8934 FILLER GROUP
Part of 837968 Transmission Group

TRANSMISSION AND DRIVETRAIN



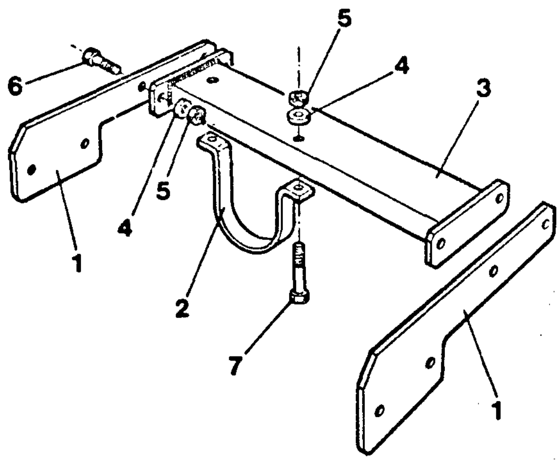
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	816381	16	BOLT		5	837912	1	DRIVE SHAFT (EACH CONTAINING)
	2	816332	8	STRAP		6	6R9122	2	UNIVERSAL JOINT KIT
	3	837911	1	DRIVE SHAFT (EACH CONTAINING)	NSSY	F	6R7601	1	DRIVESHAFT GUARD GROUP
	4	6R9122	2	UNIVERSAL JOINT KIT					

F - NOT SHOWN
NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION

P837973 Y
REV 001

837973 UNIVERSAL JOINT GROUP (TRANSMISSION)
6R7601 - PAGE 109

TRANSMISSION AND DRIVETRAIN



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7596	2	PLATE
	2	6R7599	1	PLATE
	3	6R7600	1	CROSSMEMBER AS.
M	4	8T4121	6	WASHER
M	5	8T4133	6	NUT
M	6	8T4195	4	BOLT
M	7	8T6466	2	BOLT

M - METRIC PART

P6R7601 Y

REV 000

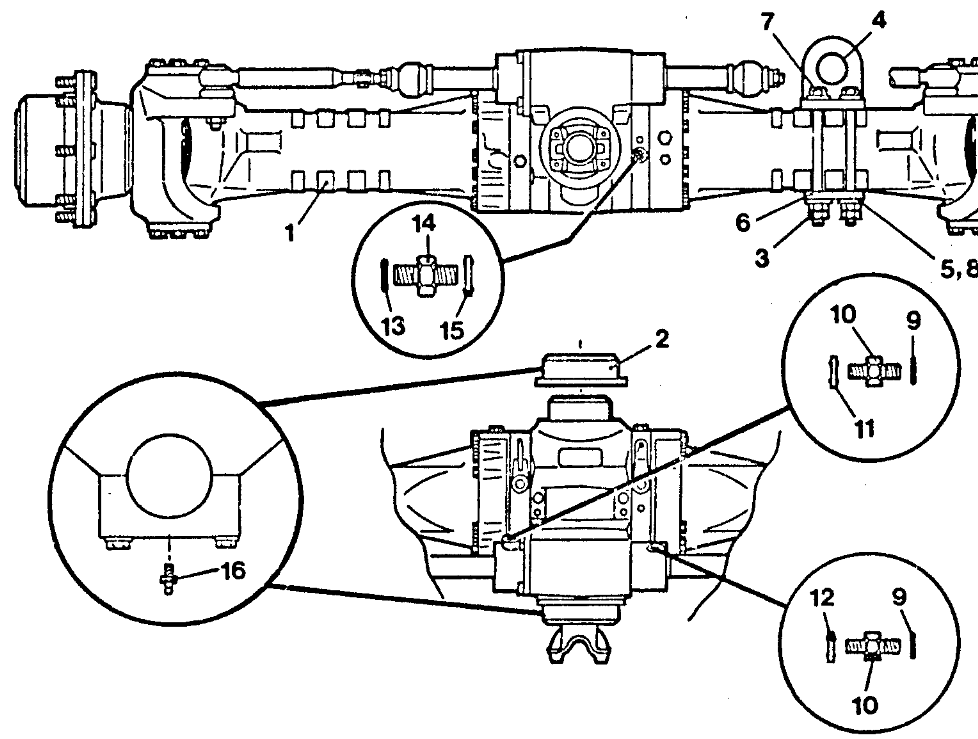
6R7601 DRIVESHAFT GUARD GROUP

PART OF 837973

MEMORANDUM

MEMORANDUM

AXLES AND BRAKES



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	986040	1	STEER / DRIVE AXLE		9	6V8397	2	O RING
	2	837961	2	BEARING		10	897886	2	ADAPTOR
M	3	6V7742	8	NUT		11	897887	1	DOWTY SEAL
	4	815497	1	BRACKET		12	985752	1	SEAL RING
M	5	816166	4	WASHER (TAPER)		13	4J5477	1	O RING (O.R.F.S.)
	6	897497	1	PLATE		14	897824	1	CONNECTOR
M	7	897990	4	BOLT		15	897936	1	SEAL
	8	8T3282	8	WASHER		16	3B8489	2	GREASE NIPPLE

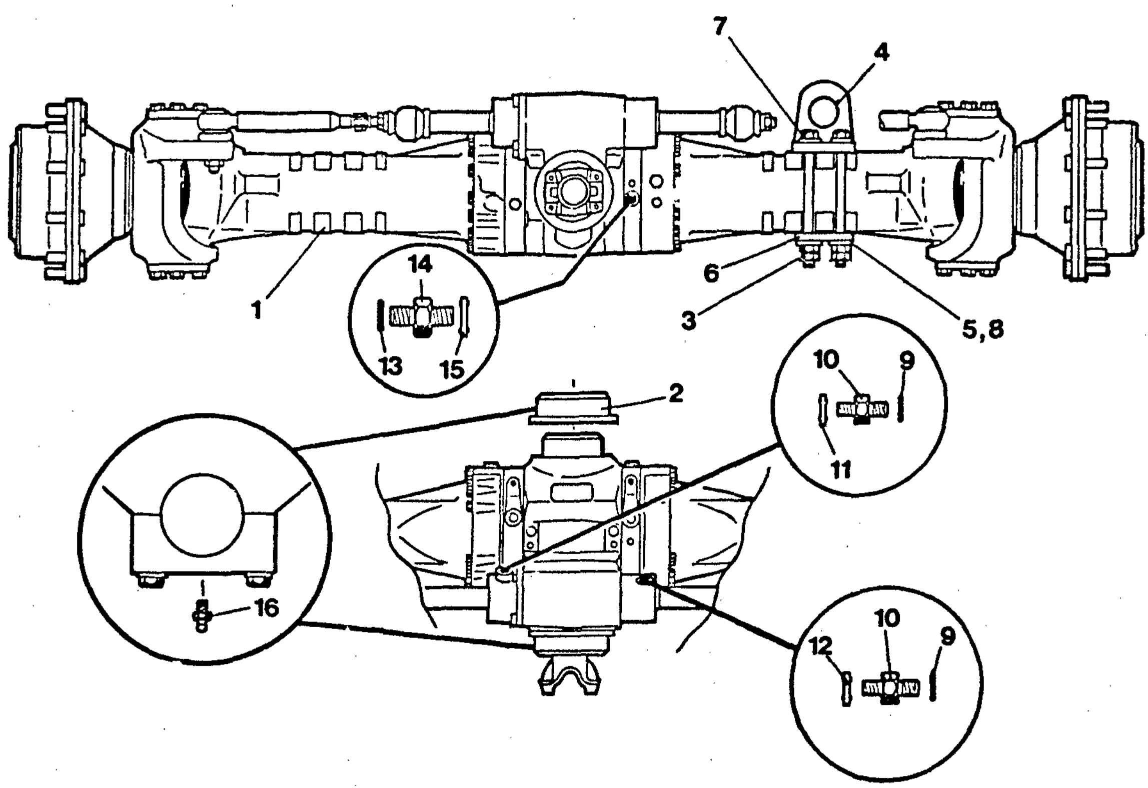
M - METRIC PART
Y - SEPARATE ILLUSTRATION

P6R9089
REV 000

6R9089 FRONT AXLE GROUP (RT80)

986040 - PAGE 115

AXLES AND BRAKES



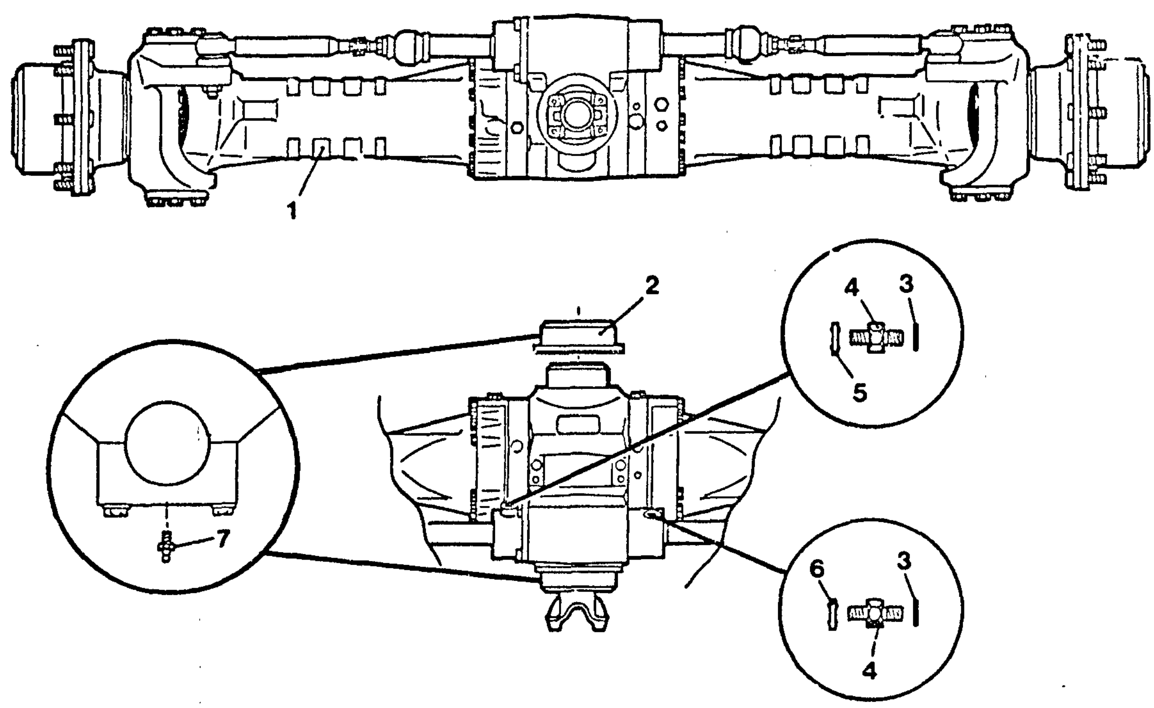
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	815509	1	STEER / DRIVE AXLE		9	6V8397	2	O RING
	2	837961	2	BEARING		10	897886	2	ADAPTOR
M	3	6V7742	8	NUT		11	897887	1	DOWTY SEAL
	4	815497	1	BRACKET		12	985752	1	SEAL RING
M	5	816166	4	WASHER (TAPER)		13	4J5477	1	O RING (O.R.F.S.)
	6	897497	1	PLATE		14	897824	1	CONNECTOR
M	7	897990	4	BOLT		15	897936	1	SEAL
	8	8T3282	8	WASHER		16	3B8489	2	GREASE NIPPLE

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P815511 Y
REV 002

815511 FRONT AXLE GROUP (RT100)

815509 - PAGE 116

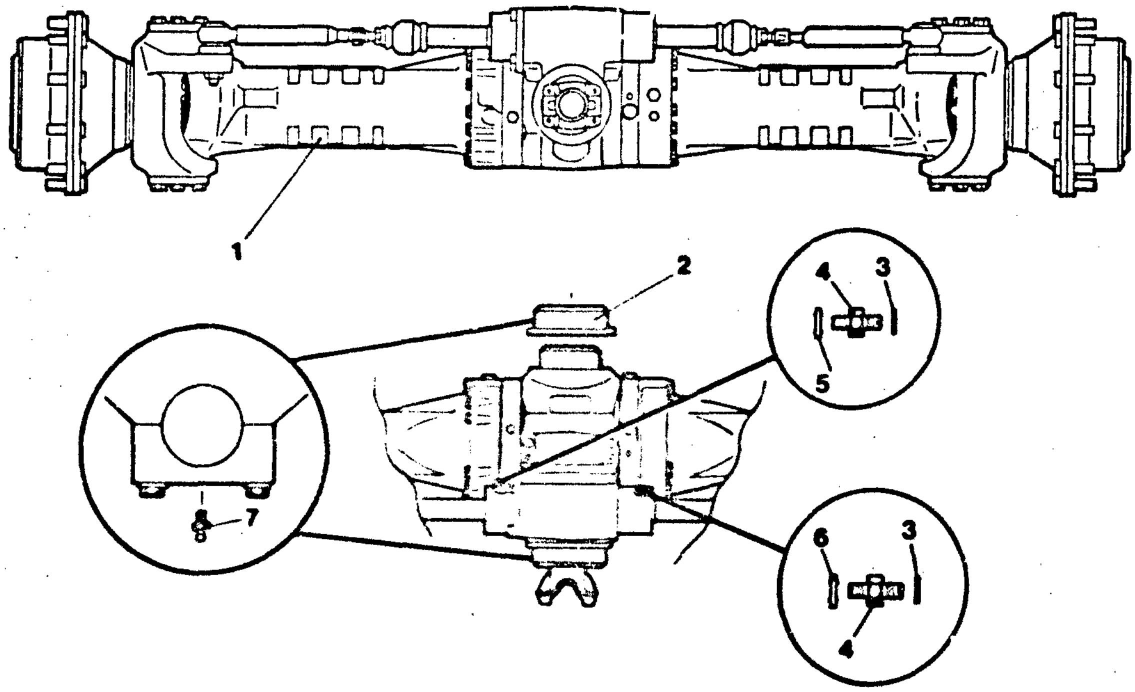


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	986041	1	STEER / DRIVE AXLE		5	897887	1	DOWTY SEAL
	2	837961	2	BEARING		6	985752	1	SEAL RING
	3	6V8397	2	O RING		7	3B8489	2	GREASE NIPPLE
	4	897886	2	ADAPTOR					

Y - SEPARATE ILLUSTRATION

P6R9091
REV 000

AXLES AND BRAKES



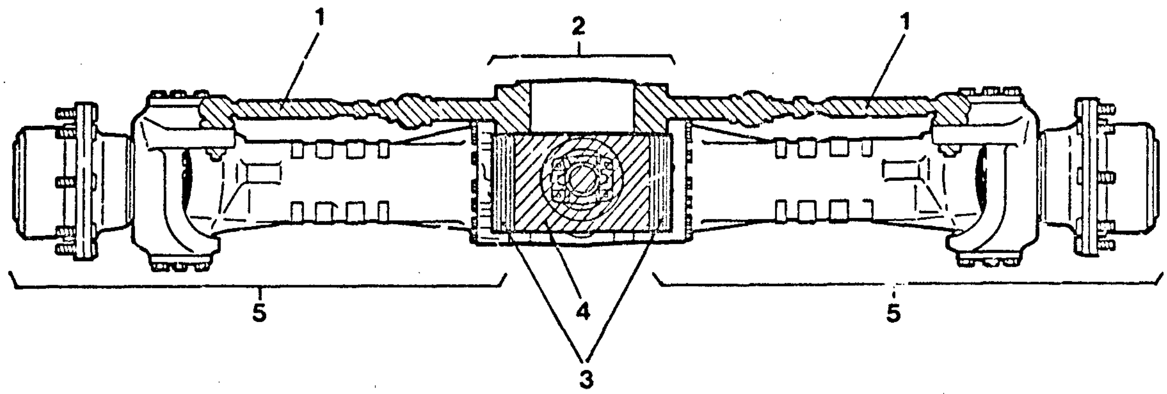
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	815510	1	STEER / DRIVE AXLE		5	897887	1	DOWTY SEAL
	2	837961	2	BEARING		6	985752	1	SEAL RING
	3	6V8397	2	O RING		7	3B8480	2	GREASE NIPPLE
	4	897886	2	ADAPTOR					

Y - SEPARATE ILLUSTRATION

P815508
REV 002

815508 REAR AXLE GROUP (RT100)
815510 - PAGE 118

AXLES AND BRAKES



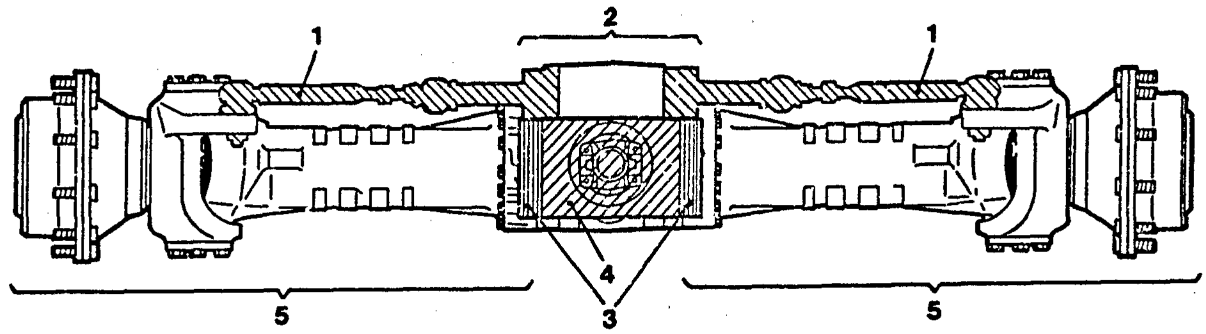
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
NSSY	1	975135	1	STEER ROD GROUP					
NSSY	2	8Q2383	1	DIFFERENTIAL CASING GROUP					
NSSY	3	8Q2447	1	BRAKE GROUP					
NSSY	4	8Q2421	1	DIFFERENTIAL GROUP					
NSSY	5	8Q2422	1	AXLE GROUP					

NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION

P986040
REV 000

986040 FRONT AXLE GROUP (STEER - DRIVE WITH DIFFERENTIAL LOCK AND PARK BRAKE) (RT80)
Part of 6R9089 Front Axle Group

975135 - PAGE 133.8Q2383 - PAGE 119.8Q2447 - PAGE 129.8Q2421 - PAGE 121.8Q2422- PAGE 125.



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
NSSY	1	975135	1	STEER ROD GROUP					
NSSY	2	8Q2333	1	DIFFERENTIAL CASING GROUP					
NSSY	3	8Q2146	1	DISC BRAKE GROUP					
NSSY	4	8Q2119	1	DIFFERENTIAL GROUP					
NSSY	5	8Q2124	1	AXLE CASING GROUP					

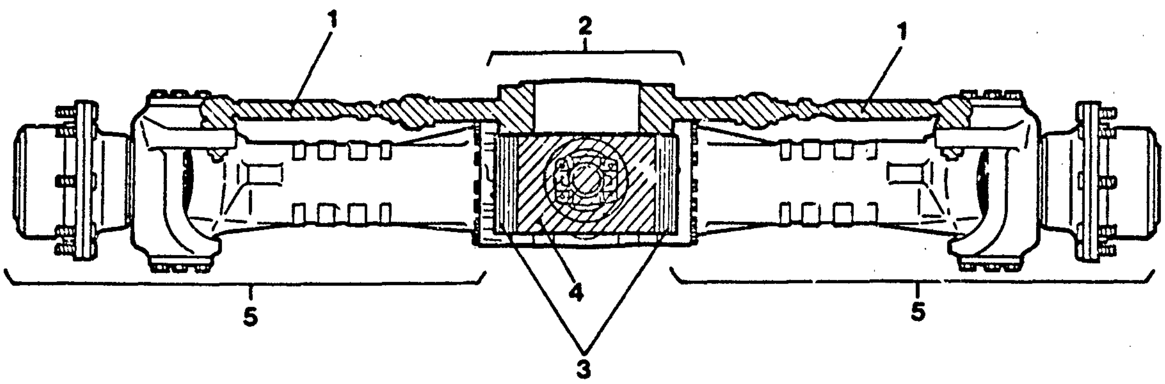
NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION

P815509 Y
REV000

815509 FRONT AXLE GROUP (STEER -DRIVE, WITH DIFFERENTIAL LOCK AND PARK BRAKE) (RT100)
Part of 815511 Front Axle GP

975135 - PAGE 133 . 8Q2383 - PAGE 119 . 8Q2146 - PAGE 130 . 8Q2119 - PAGE 122 . 8Q2124 - PAGE 127.

AXLES AND BRAKES



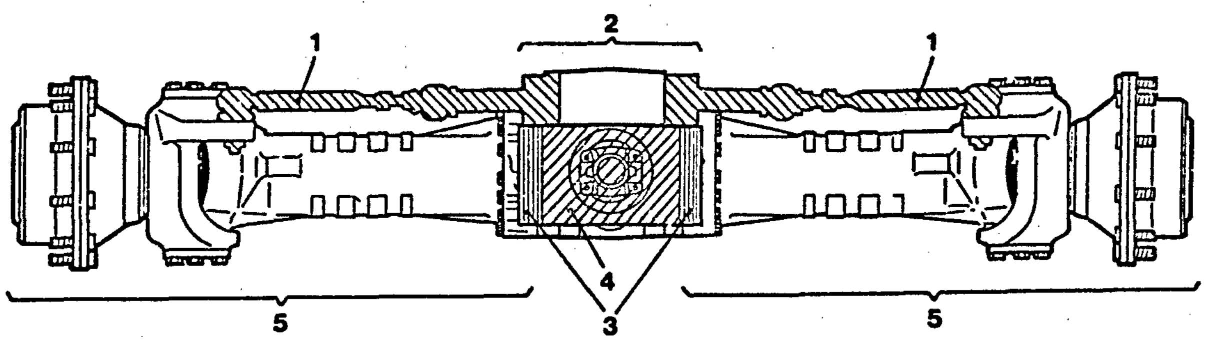
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
NSSY	1	975135	1	STEER ROD GROUP					
NSSY	2	8Q2399	1	DIFFERENTIAL CASING GROUP					
NSSY	3	8Q2448	1	BRAKE GROUP					
NSSY	4	8Q2420	1	DIFFERENTIAL GROUP					
NSSY	5	8Q2422	1	AXLE GROUP					

NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION

P986041
REV 000

986041 REAR AXLE GROUP (STEER - DRIVE) (RT80)
Part of 6R9091 Rear Axle Group

975135 - PAGE 133 .8Q2399 - PAGE 120 .8Q2448 - PAGE 131.8Q2420 - PAGE 123 .8Q2422 - PAGE 125 .



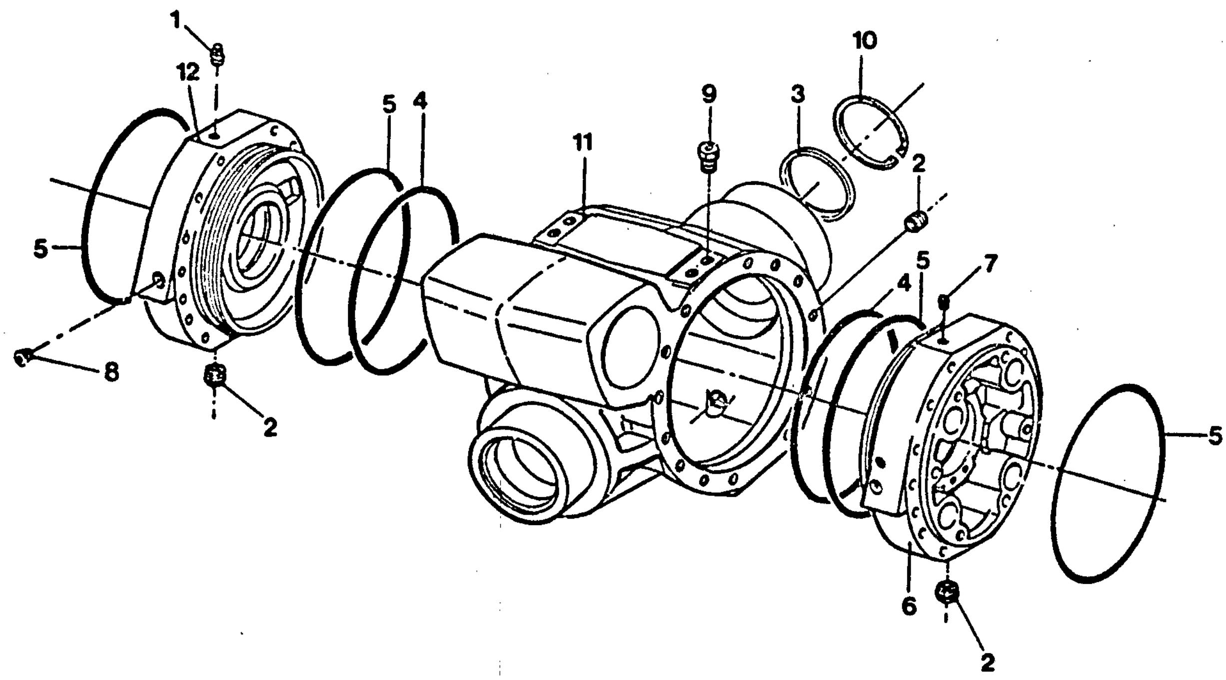
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
NSSY	1	975135	1	STEER ROD GROUP					
NSSY	2	8Q2399	1	DIFFERENTIAL CASING GROUP					
NSSY	3	8Q2400	1	DISC BRAKE GROUP					
NSSY	4	8Q2402	1	DIFFERENTIAL GROUP					
NSSY	5	8Q2124	1	AXLE CASING GROUP					

NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION

P815510
REV000

815510 REAR AXLE GROUP (STEER -DRIVE) (RT100)
Part of 815508 Front Axle GP

975135 - PAGE 133, 8Q2399 - PAGE 120, 8Q2400 - PAGE 132, 8Q2402 - PAGE 124, 8Q2124 - PAGE 127.

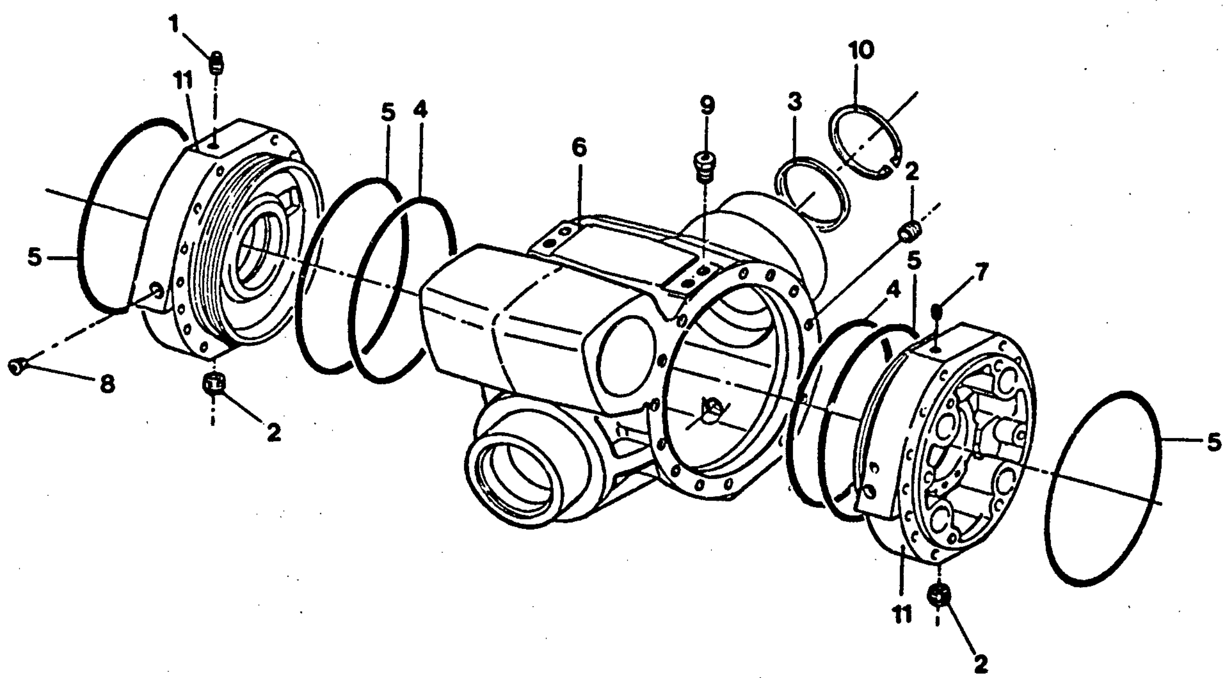


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7T1587	1	VENT
	2	7T1609	3	MAGNETIC PLUG
	3	8Q2151	1	COVER
	4	8Q2384	2	O. RING
	5	975144	4	O. RING
	6	975142	1	AXLE CASE
M	7	975147	1	PLUG
M	8	975149	1	PLUG
	9	975150	2	ADAPTOR
M	10	975152	1	CIRCILP
	11	975145	1	CASE
	12	975148	1	AXLE CASE

M - METRIC PART

P8Q2383
REV 000

8Q2383 DIFFERENTIAL CASING GROUP
Part of 986040 And 815509 Front Axle Groups

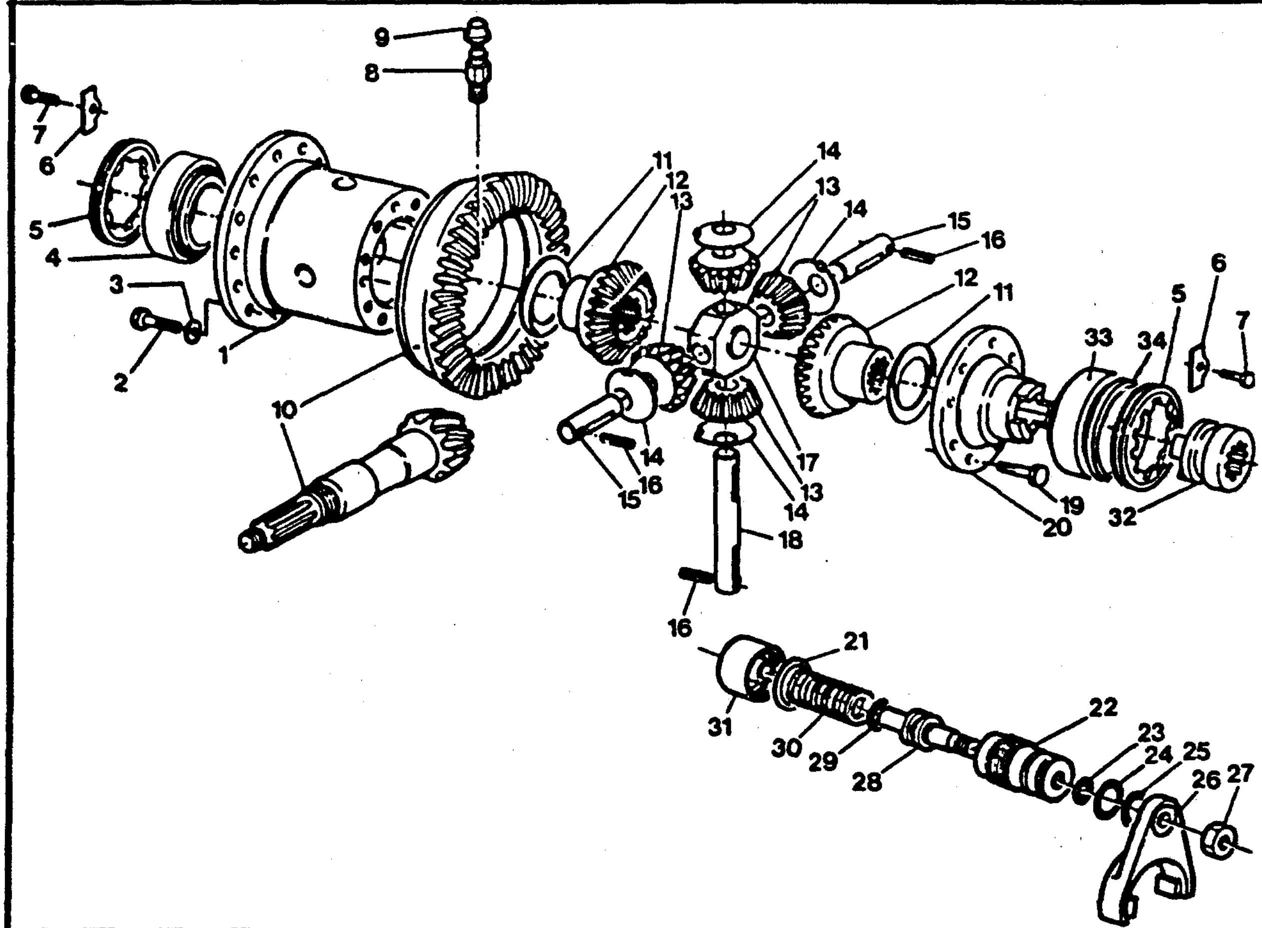


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	7T1587	1	VENT	M	7	975147	1	PLUG
	2	7T1609	3	MAGNETIC PLUG	M	8	975149	2	PLUG
	3	8Q2151	1	COVER		9	975150	2	ADAPTOR
	4	8Q2384	2	O. RING	M	10	975152	1	CIRCILP
	5	975144	4	O. RING		11	975310	2	AXLE CASE
	6	975145	1	CASE					

M - METRIC PART

P8Q2399 Y
REV 000

8Q2399 DIFFERENTIAL CASING GROUP
Part of 815510 And 986041 Rear Axle Groups



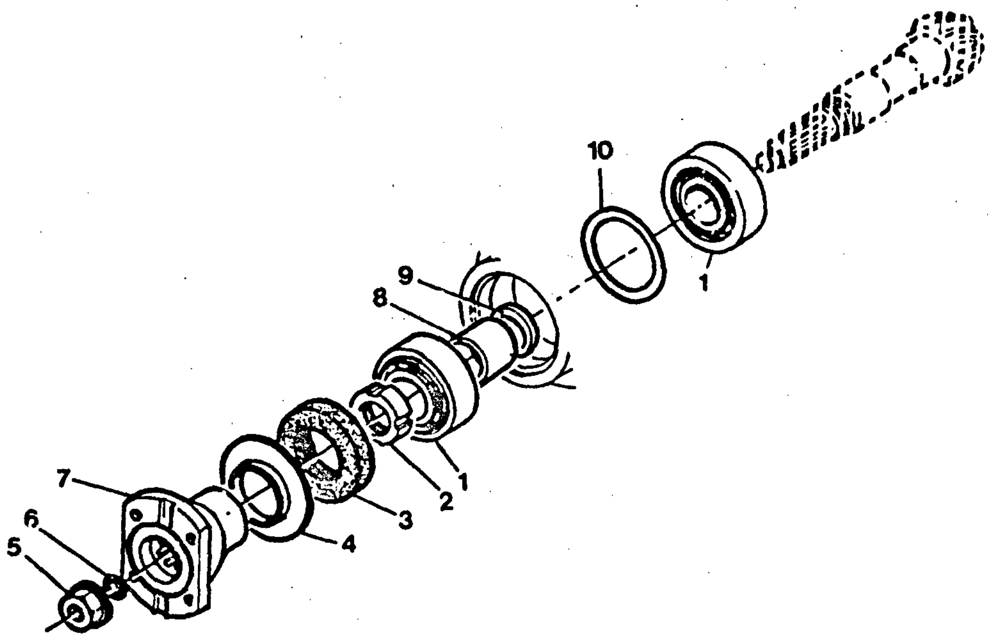
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	975183	1	CASE		19	6V8097	8	BOLT
M	2	975184	16	BOLT		20	975200	1	COVER
M	3	975185	16	LOCKWASHER	M	21	975201	1	SHIM
	4	6Y2943	1	CUP		22	975202	1	CYLINDER
		6Y2942	1	CONE		23	975203	1	O RING
	5	975187	2	RING NUT		24	975204	1	O RING
	6	975188	2	SUPPORT		25	975205	1	O RING
M	7	2W9513	2	BOLT		26	975206	1	LEVER
	8	8Q2121	1	NIPPLE	M	27	8T0384	1	NUT
	9	8Q2122	1	PLUG		28	975208	1	PISTON
	10	8Q2423	1	BEVEL GEAR SET		29	975209	1	O RING
	11	975191	2	DISC		30	975210	1	SPRING
	12	975192	2	SIDE GEAR		31	975211	1	RING NUT
	13	975193	4	PINION		32	975212	1	CHANGE SELECTOR
	14	975194	4	DISC		33	6Y2945	1	CUP
M	15	975195	2	PIN			6Y2944	1	CONE
M	16	975196	3	ROLL PIN		34	975233	1	SPACER
	17	975197	1	RETAINER					
	18	975198	1	PIN					

M - METRIC PART

P8Q2421

REV 000

8Q2421 DIFFERENTIAL GROUP (1 of 2)
Part of 986040 Front Axle Group (RT80)



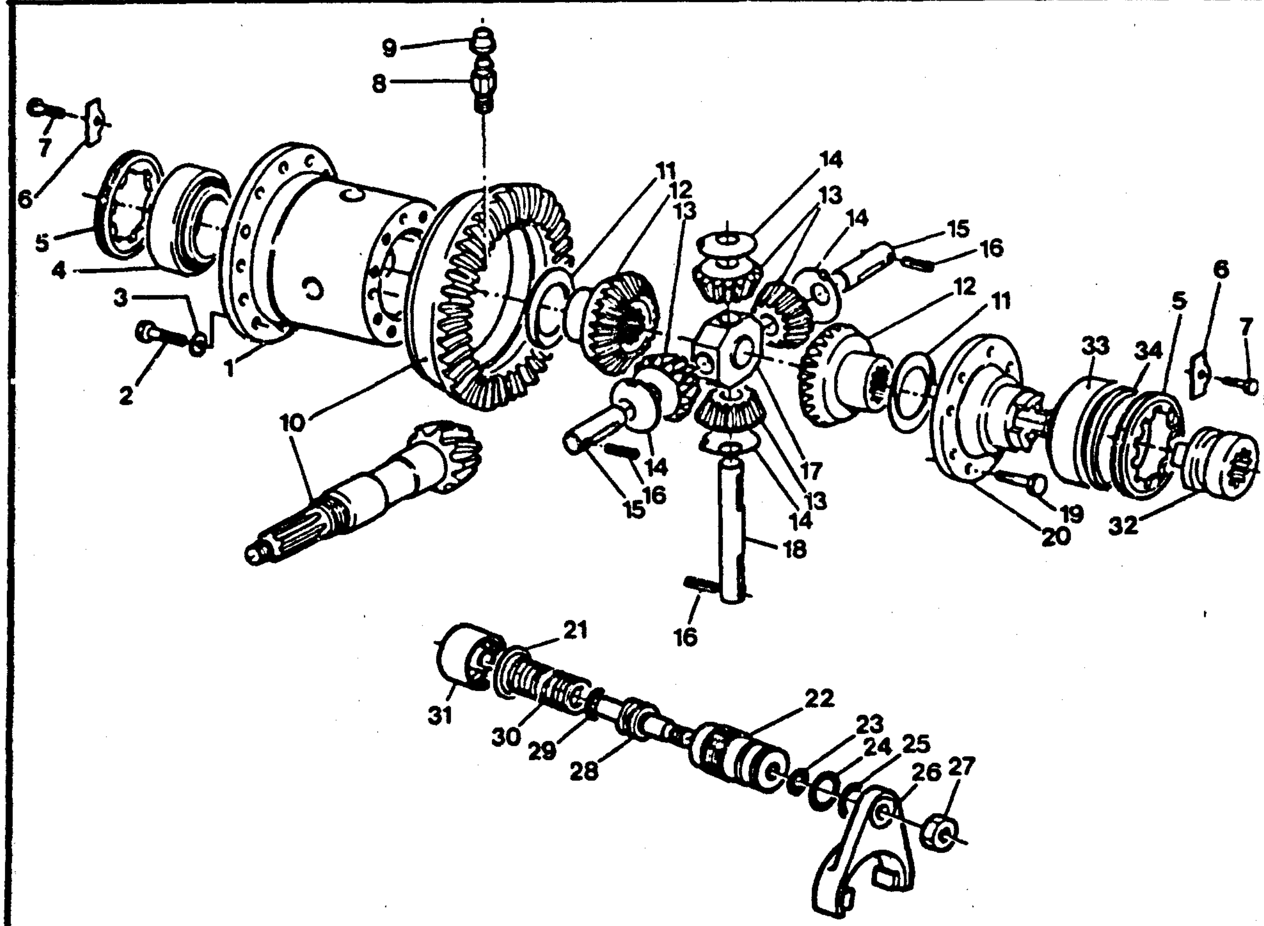
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3N6408	2	CUP	BM		975220	-	SHIM 0.35mm THICK
		083175	2	CONE	BM		975221	-	SHIM 0.40mm THICK
	2	975214	1	RING NUT	BM	8	975222	-	SHIM 0.45mm THICK
M	3	975215	1	SEAL	BM		8Q2391	-	SHIM 0.55mm THICK
	4	975216	1	COVER PLATE	BM		8Q2392	-	SHIM 0.50mm THICK
	5	975217	1	NUT	BM		8Q2393	-	SHIM 0.60mm THICK
M	6	975218	1	O RING			975224	1	SPACER 42.02mm LONG
	7	975219	1	FLANGE			8Q2396	1	SPACER 42.04mm LONG
						9	8Q2397	1	SPACER 42.06mm LONG
							8Q2398	1	SPACER 42.08mm LONG
					BM		975228	-	SHIM 0.20mm THICK
					BM		975229	-	SHIM 0.25mm THICK
					BM	10	8Q2394	-	SHIM 0.30mm THICK
					BM		8Q2395	-	SHIM 0.35mm THICK

M - METRIC PART
P - USE AS REQUIRED

P8Q2421
REV 000

8Q2421 DIFFERENTIAL GROUP (2 of 2)
Part of 986040 Front Axle Group (RT80)

AXLES AND BRAKES



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	975183	1	CASE		19	6V8097	8	BOLT
M	2	975184	16	BOLT		20	975200	1	COVER
M	3	975185	16	LOCKWASHER	M	21	975201	1	SHIM
	4	6Y2943	1	CUP		22	975202	1	CYLINDER
		6Y2942	1	CONE		23	975203	1	O RING
	5	975187	2	RING NUT		24	975204	1	O RING
	6	975188	2	SUPPORT		25	975205	1	O RING
M	7	2W9513	2	BOLT		26	975206	1	LEVER
	8	8Q2121	1	NIPPLE	M	27	8T0384	1	NUT
	9	8Q2122	1	PLUG		28	975208	1	PISTON
	10	8Q2120	1	BEVEL GEAR SET		29	975209	1	O RING
	11	975191	2	DISC		30	975210	1	SPRING
	12	975192	2	SIDE GEAR		31	975211	1	RING NUT
	13	975193	4	PINION		32	975212	1	CHANGE SELECTOR
	14	975194	4	DISC		33	6Y2945	1	CUP
M	15	975195	2	PIN			6Y2944	1	CONE
M	16	975196	3	ROLL PIN		34	975233	1	SPACER
	17	975197	1	RETAINER					
	18	975198	1	PIN					

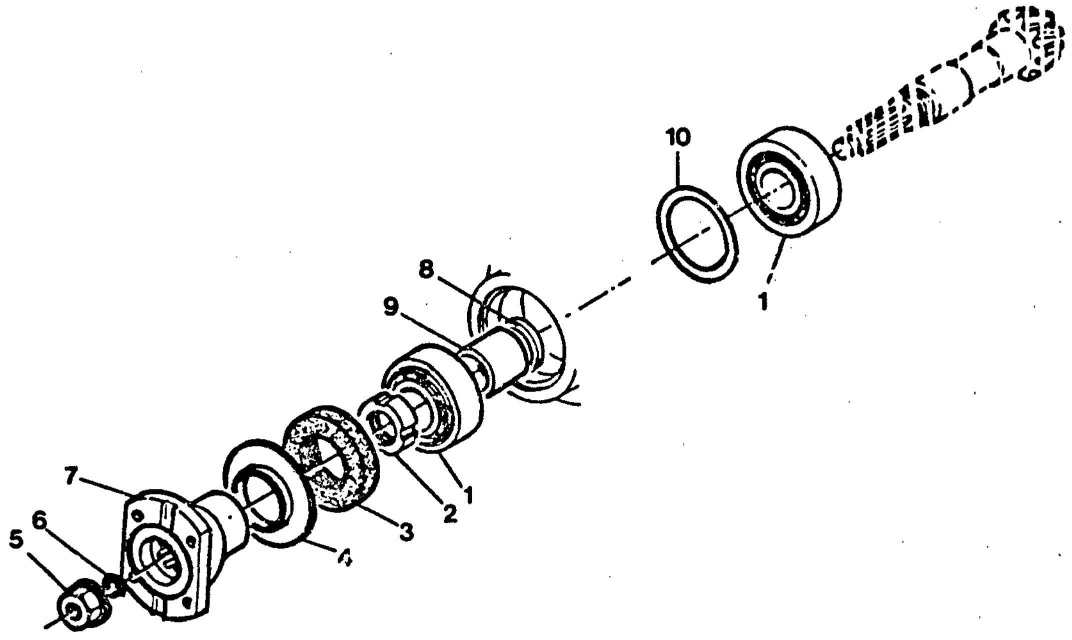
M - METRIC PART

P8Q2119

REV 000

8Q2119 DIFFERENTIAL GROUP (1of 2)
Part of 815509 Front Axle Group (RT100)

AXLES AND BRAKES

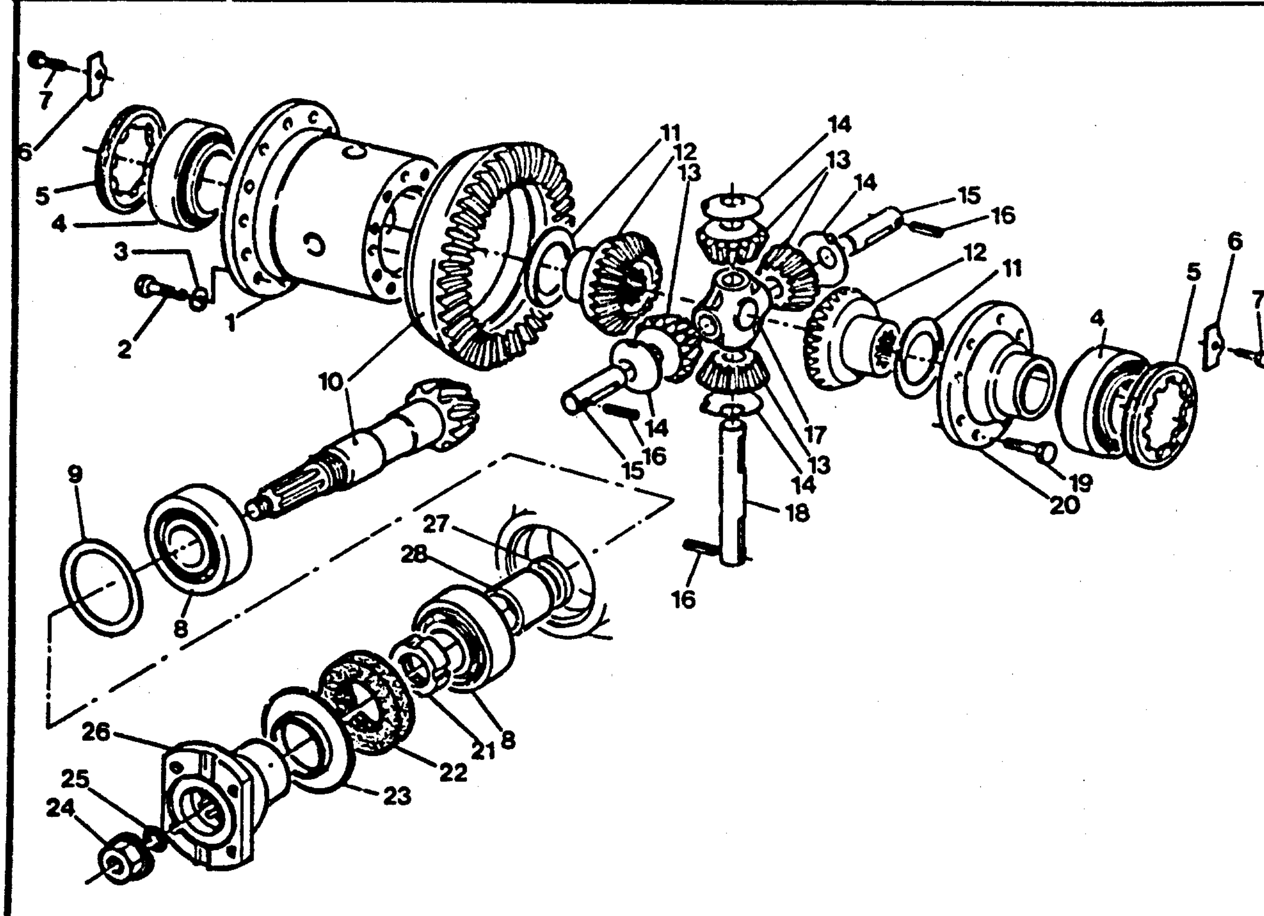


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3N6408	2	CUP	BM	8	975220	-	SHIM 0.35mm THICK
	1	083175	2	CONE	BM	8	975221	-	SHIM 0.40mm THICK
	2	975214	1	RING NUT	BM	8	975222	-	SHIM 0.45mm THICK
M	3	975215	1	SEAL	BM	8	8Q2391	-	SHIM 0.55mm THICK
	4	975216	1	COVER PLATE	BM	8	8Q2392	-	SHIM 0.50mm THICK
	5	975217	1	NUT	BM	8	8Q2393	-	SHIM 0.60mm THICK
M	6	975218	1	O RING		9	975224	1	SPACER 42.02mm LONG
	7	975219	1	FLANGE		9	8Q2396	1	SPACER 42.04mm LONG
						9	8Q2397	1	SPACER 42.06mm LONG
						9	8Q2398	1	SPACER 42.08mm LONG
					BM	10	975228	-	SHIM 0.20mm THICK
					BM	10	975229	-	SHIM 0.25mm THICK
					BM	10	8Q2394	-	SHIM 0.30mm THICK
					BM	10	8Q2395	-	SHIM 0.35mm THICK

M - METRIC PART
B - USE AS REQUIRED

P8Q2119
REV 000

8Q2119 DIFFERENTIAL GROUP (2of 2)
Part of 815509 Front Axle Group (RT100)



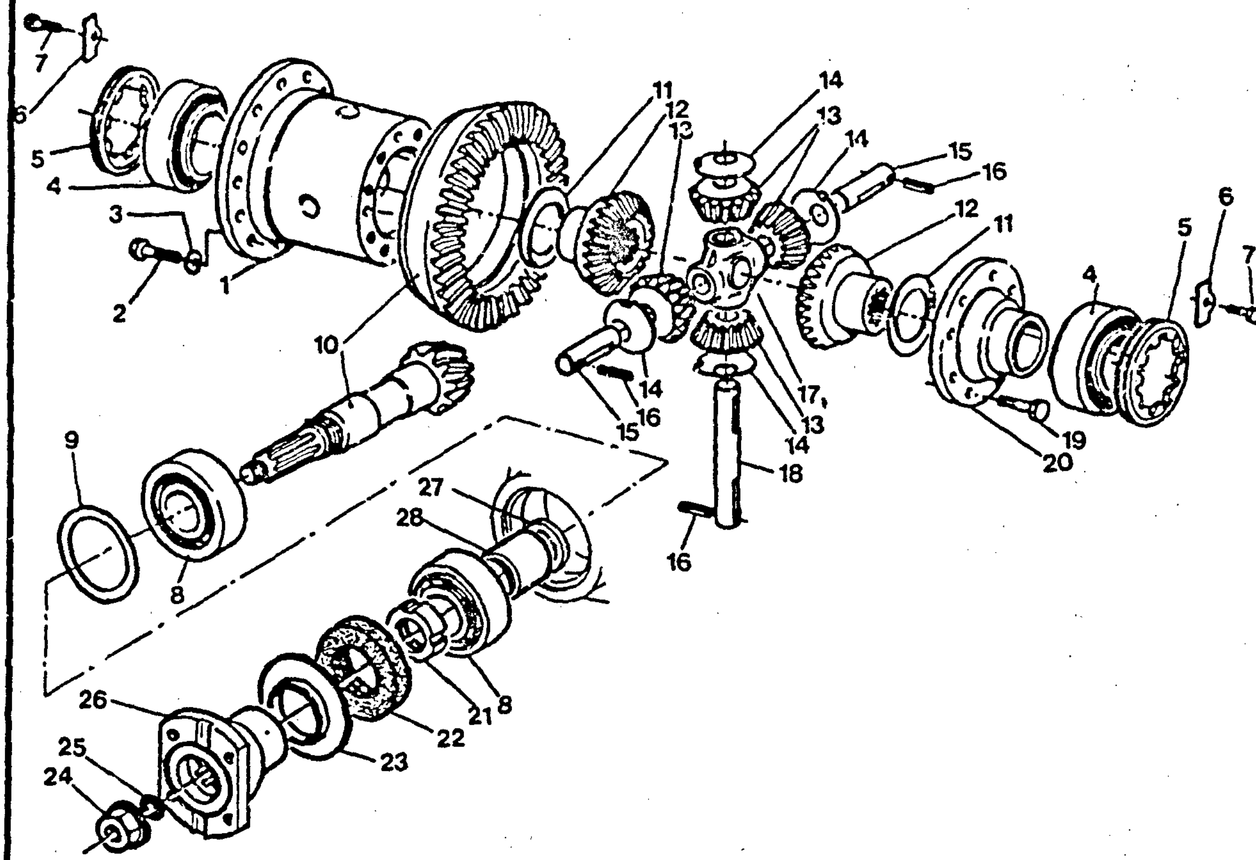
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	975183	1	CASE
M	2	975184	16	BOLT
M	3	975185	16	LOCKWASHER
	4	6Y2943	1	CUP
		6Y2942	1	CONE
	5	975187	2	RING NUT
	6	975188	2	SUPPORT
M	7	2W9513	2	BOLT
	8	3N6408	2	CUP
		083175	2	CONE
BM	9	975228	-	SHIM 0.20mm THICK
BM		975229	-	SHIM 0.25mm THICK
BM		8Q2394	-	SHIM 0.30mm THICK
BM		8Q2395	-	SHIM 0.35mm THICK
	10	8Q2423	1	BEVEL GEAR SET
	11	975191	2	DISC
	12	975192	2	SIDE GEAR
	13	975193	4	PINION
	14	975194	4	DISC
	15	975195	2	PIN
M	16	975196	3	ROLL PIN
	17	975197	1	RETAINER
	18	975198	1	PIN
M	19	6V3668	8	BOLT
	20	8Q2401	1	COVER
	21	975214	1	RING NUT
M	22	975215	1	SEAL
	23	975216	1	COVER PLATE
	24	975217	1	NUT
M	25	975218	1	O RING
	26	975219	1	FLANGE
BM	27	975220	-	SHIM 0.35mm THICK
BM		975221	-	SHIM 0.40mm THICK
BM		975222	-	SHIM 0.45mm THICK
BM		8Q2391	-	SHIM 0.55mm THICK
BM		8Q2392	-	SHIM 0.50mm THICK
BM		8Q2393	-	SHIM 0.60mm THICK
	28	975224	1	SPACER 42.02 mm LONG
		8Q2396	1	SPACER 42.04 mm LONG
		8Q2397	1	SPACER 42.06 mm LONG
		8Q2398	1	SPACER 42.08 mm LONG

B - USE AS REQUIRED
M - METRIC PART

P8Q2420
REV 001

8Q2420 DIFFERENTIAL GROUP
Part of 986041 Rear Axle Group (RT80)

AXLES AND BRAKES



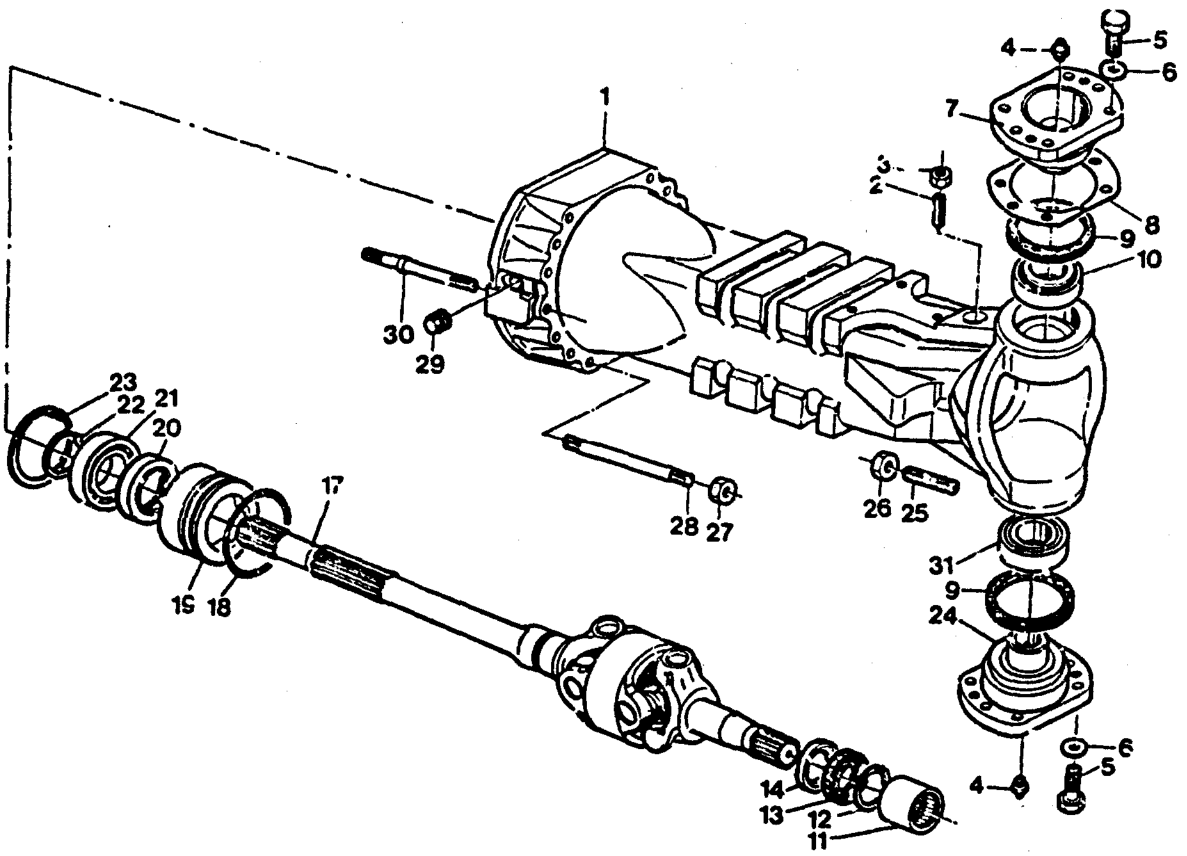
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	975183	1	CASE		17	975197	1	RETAINER
M	2	975184	16	BOLT		18	975198	1	PIN
M	3	975185	16	LOCKWASHER	M	19	8V3668	8	BOLT
	4	6Y2943	1	CUP		20	8Q2401	1	COVER
		6Y2942	1	CONE		21	975214	1	RING NUT
	5	975187	2	RING NUT	M	22	975215	1	SEAL
	6	975188	2	SUPPORT		23	975216	1	COVER PLATE
M	7	2W9513	2	BOLT		24	975217	1	NUT
	8	3N6408	2	CUP	M	25	975218	1	O RING
		083175	2	CONE		26	975219	1	FLANGE
BM		975228	-	SHIM 0.20mm THICK	BM		975220	-	SHIM 0.35mm THICK
BM	9	975229	-	SHIM 0.25mm THICK	BM	27	975221	-	SHIM 0.40mm THICK
BM		8Q2394	-	SHIM 0.30mm THICK	BM		975222	-	SHIM 0.45mm THICK
BM		8Q2395	-	SHIM 0.35mm THICK	BM		8Q2391	-	SHIM 0.55mm THICK
	10	8Q2120	1	BEVEL GEAR SET	BM		8Q2392	-	SHIM 0.50mm THICK
	11	975191	2	DISC	BM		8Q2393	-	SHIM 0.60mm THICK
	12	975192	2	SIDE GEAR			975224	1	SPACER 42.02mm LONG
	13	975193	4	PINION			8Q2396		SPACER 42.04mm LONG
	14	975194	4	DISC		28	8Q2397	1	SPACER 42.06mm LONG
	15	975195	2	PIN			8Q2398	1	SPACER 42.08mm LONG
M	16	975196	3	ROLL PIN					

B - USE AS REQUIRED
M - METRIC PART

P8Q2402
REV 001

8Q2402 DIFFERENTIAL GROUP
Part of 815510 Rear Axle Group (RT100)

AXLES AND BRAKES



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	975235	2	AXLE CASE
M	2	975236	2	STUD
M	3	GV8149	2	NUT
	4	975238	4	NIPPLE
M	5	975239	24	BOLT
	6	975240	24	LOCKWASHER
	7	975241	2	PIVOT PIN
B		975242	-	SHIM 0.10mm THICK
B		975243	-	SHIM 0.25mm THICK
B	8	975244	-	SHIM 0.50mm THICK
	9	975245	4	SEAL
	10	2P8120	2	CUP
		2P8119	2	CONE
	11	975287	2	BEARING
	12	975208	2	SNAP RING
	13	975289	2	SEAL
	14	975290	2	DUST EXCLUDER

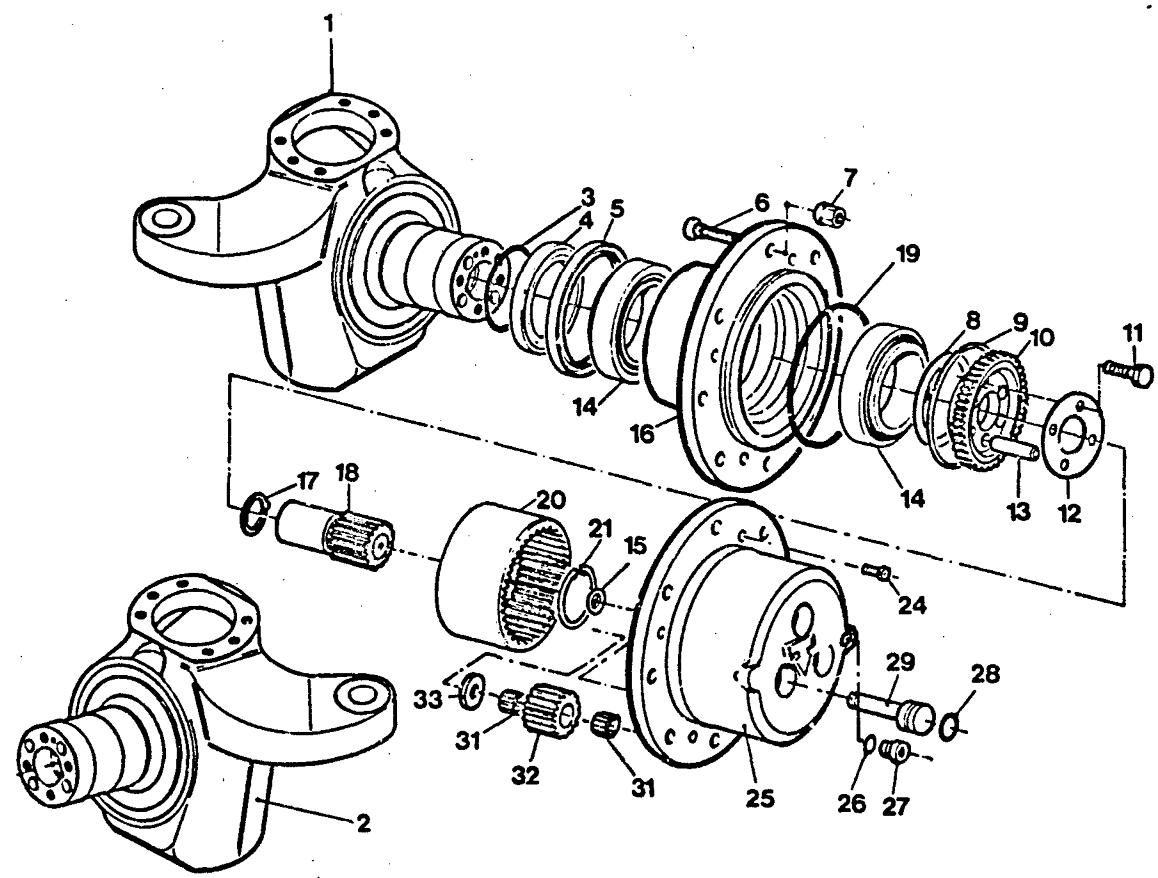
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	17	6R8914	2	HALF SHAFT
	18	975294	2	O RING
	19	975295	2	REDUCING BUSH
	20	975296	2	SEAL
	21	1T0043	2	BEARING
M	22	975298	2	SNAP RING
M	23	975152	2	SNAP RING
	24	975300	2	PIVOT PIN
	25	975301	4	ADJUSTING BOLT
M	26	975302	4	NUT
M	27	975303	28	NUT
	28	975304	24	STUD
	29	8Q2145	2	PLUG
	30	975307	4	STUD
	31	4D8649	2	CUP
		4D8648	2	CONE

B - USE AS REQUIRED
M - METRIC PART

P8Q2422
REV 001

8Q2422 AXLE CASING GROUP (1 OF 2)
Part of 986040 and 986041 Front and Rear Axle Groups (RT80)

AXLES AND BRAKES



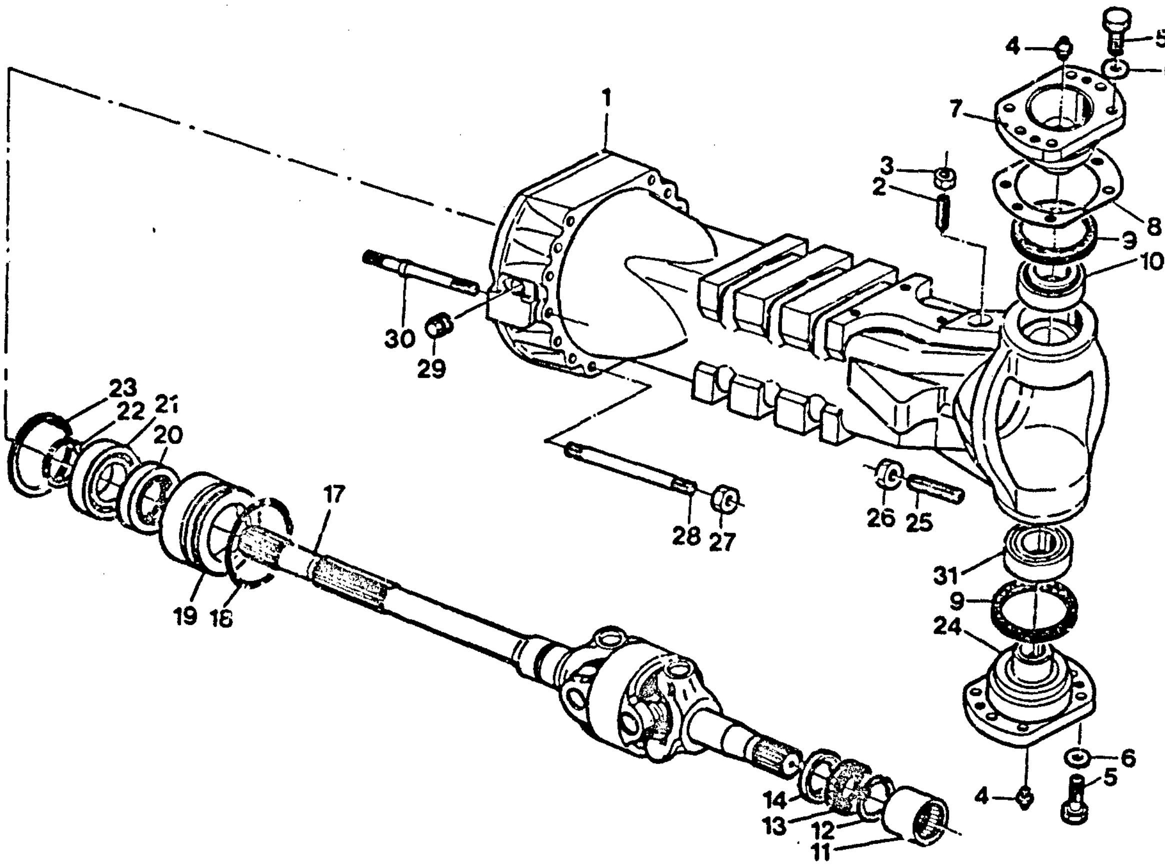
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	975247	1	STEERING CASE		18	8Q2426	2	PINION
	2	975248	1	STEERING CASE		19	975345	2	O RING
	3	975249	2	O RING		20	8Q2427	2	RING GEAR
	4	975250	2	SPACER		21	8Q2428	2	SNAP RING
M	5	975251	2	SEAL	M	24	975358	8	CAPSCREW
	6	975312	16	WHEEL STUD		25	8Q2431	2	CARRIER
	7	975253	16	NUT	M	26	975279	2	SEALING WASHER
BM		975254	-	SHIM 0.15mm THICK		27	975280	2	PLUG
BM	8	975255	-	SHIM 0.20mm THICK		28	8Q2429	6	O RING
BM		975256	-	SHIM 0.50mm THICK		29	8Q2430	6	PIN
B		8Q2140	-	SHIM 0.25mm THICK		31	8Q2433	12	BEARING
B		8Q2141	-	SHIM 0.30mm THICK		32	8Q2432	6	PLANET GEAR
	9	8Q2424	2	SNAP RING		33	8Q2434	6	WASHER
	10	8Q2425	2	GEAR					
	11	975261	8	BOLT					
	12	975262	2	LOCKING PLATE					
	13	975263	8	DOWEL					
	14	975264	4	BEARING					
	15	8Q2129	2	WASHER					
	16	975331	2	HUB					
	17	975481	2	FRICTION WASHER					

B - USE AS REQUIRED
M - METRIC PART

P8Q2422
REV 001

8Q2422 AXLE CASING GROUP (2 OF 2)
Part of 986040 and 986041 Front and Rear Axle Groups (RT80)

AXLES AND BRAKES



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	975235	2	AXLE CASE
M	2	975236	2	STUD
M	3	6V8149	2	NUT
	4	975238	4	NIPPLE
M	5	975239	24	BOLT
	6	975240	24	LOCKWASHER
	7	975241	2	PIVOT PIN
B		975242	-	SHIM 0.10mm THICK
B		975243	-	SHIm 0.25mm THICK
B	8	975244	-	SHIM 0.50mm THICK
	9	975245	4	SEAL
	10	2P8120	2	CUP
		2P8119	2	CONE
	11	975287	2	BEARING
	12	975288	2	SNAP RING
	13	975289	2	SEAL
	14	975290	2	DUST EXCLUDER

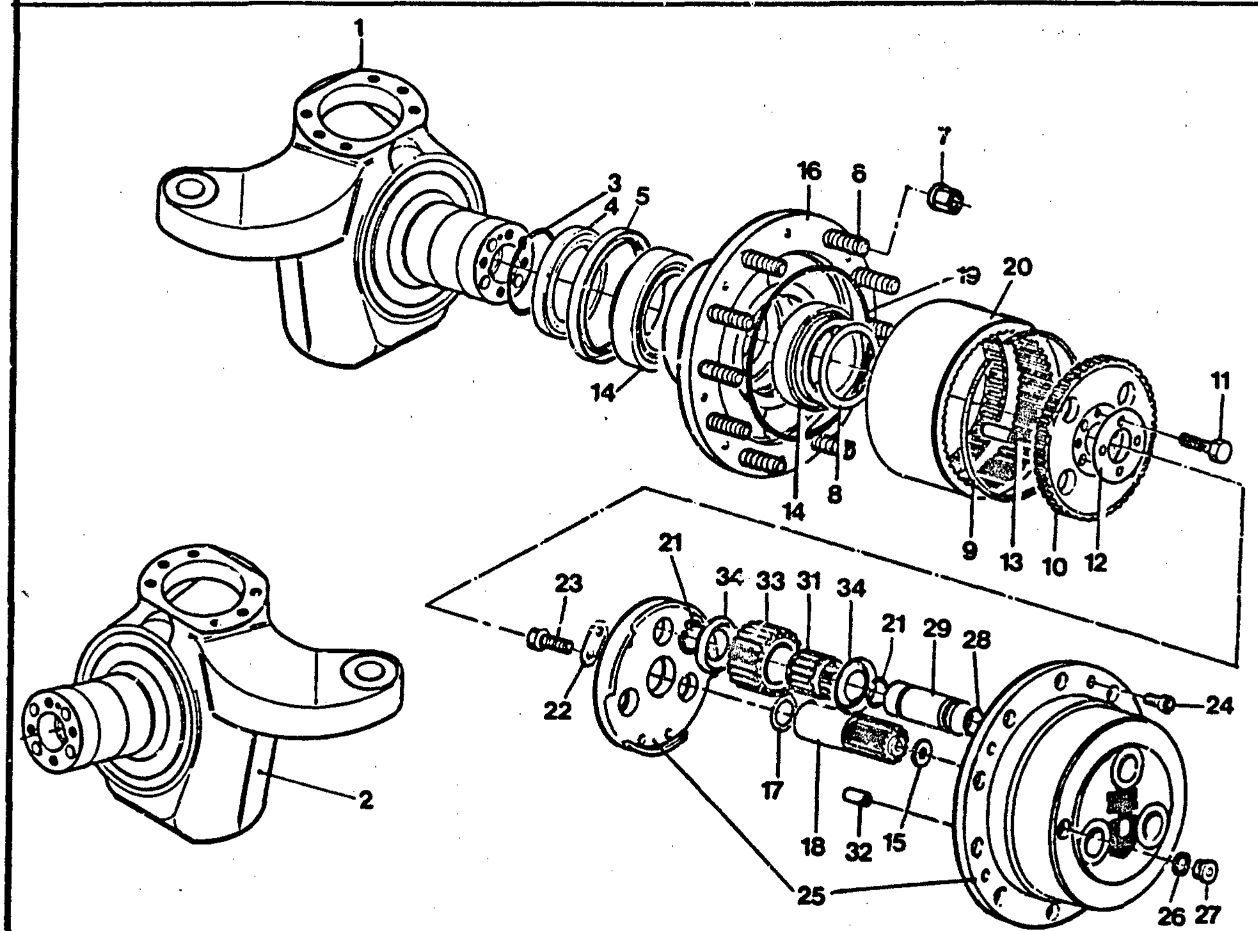
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	17	6R8914	2	HALF SHAFT
	18	975294	2	O RING
	19	975295	2	REDUCING BUSH
	20	975296	2	SEAL
	21	1T0043	2	BEARING
M	22	975298	2	SNAP RING
M	23	975152	2	SNAP RING
	24	975300	2	PIVOT PIN
	25	975301	4	ADJUSTING BOLT
M	26	975302	4	NUT
M	27	975303	28	NUT
	28	975304	24	STUD
	29	8Q2145	2	PLUG
	30	975307	4	STUD
	31	4D8649	2	CUP
		4D3648	2	CONE

B - USE AS REQUIRED
M - METRIC PART

P8Q2124
REV 001

8Q2124 AXLE CASING GROUP (1 OF 2)
Part of 815509 and 815510 Front and Rear Axle Groups (RT100)

AXLES AND BRAKES



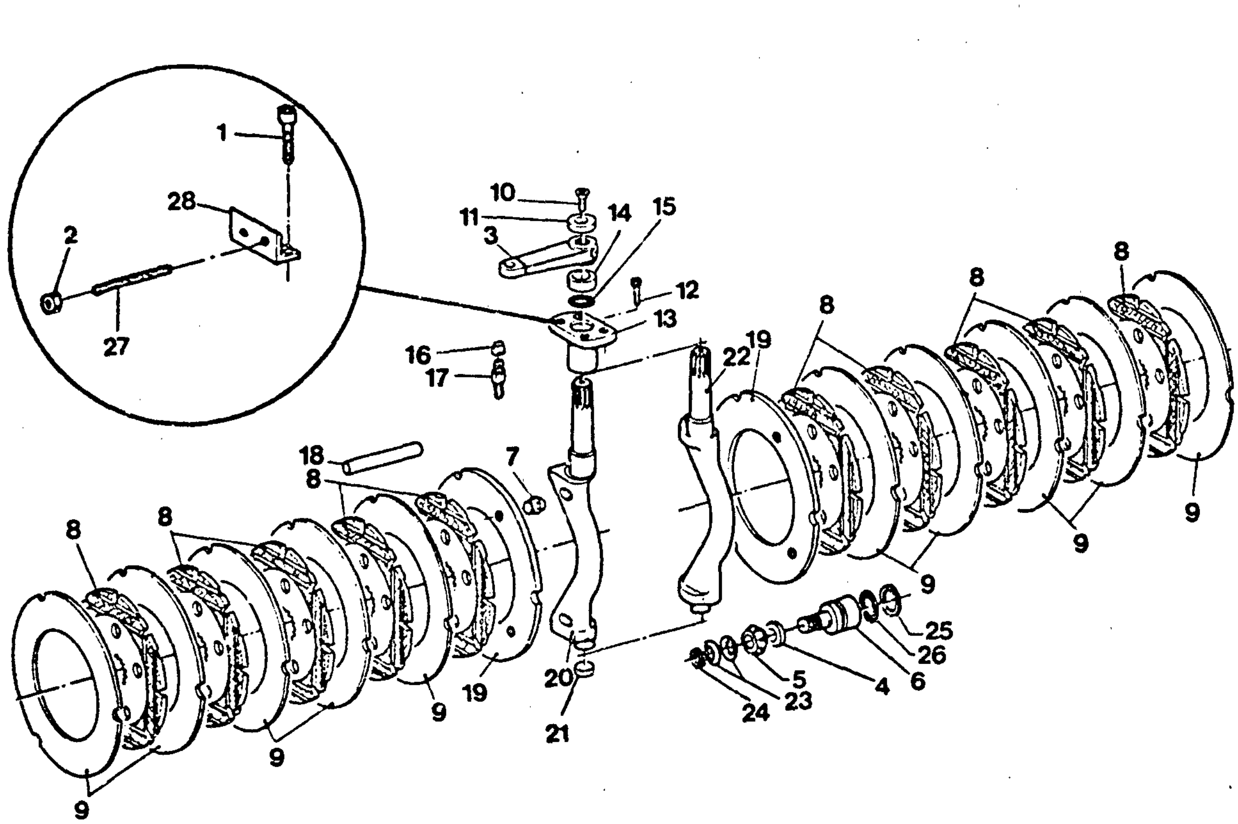
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	975247	1	STEERING CASE		18	8Q2125	2	PINION
	2	975248	1	STEERING CASE		19	8Q2136	2	O RING
	3	975249	2	O RING		20	8Q2126	2	RING GEAR
	4	975250	2	SPACER		21	8Q2139	12	SNAP RING
M	5	975251	2	SEAL		22	8Q2133	6	DISC
	6	975312	20	WHEEL STUD	M	23	8Q2144	12	BOLT
	7	975253	20	NUT	M	24	975358	10	CAPSCREW
BM		975254	-	SHIM 0.15mm THICK		25	8Q2128	2	CARRIER
BM		975255	-	SHIM 0.20mm THICK	M	26	975279	2	SEALING WASHER
BM	8	975256	-	SHIM 0.50mm THICK		27	975280	2	PLUG
BM		8Q2140	-	SHIM 0.25mm THICK		28	8Q2135	6	O RING
BM		8Q2141	-	SHIM 0.30mm THICK		29	8Q2131	6	PIN
	9	8Q2138	2	SNAP RING		31	8Q2132	6	BEARING
	10	8Q2123	2	GEAR		32	8Q2142	6	DOWEL
	11	975261	8	BOLT		33	8Q2127	6	PLANET GEAR
	12	975262	2	LOCKING PLATE		34	8Q2137	12	WASHER
	13	975263	8	DOWEL					
	14	975264	4	BEARING					
	15	8Q2129	2	WASHER					
	16	8Q2134	2	HUB					
	17	8Q2130	2	FRICTION WASHER					

B - USE AS REQUIRED
M - METRIC PART

P8Q2124
REV 001

8Q2124 AXLE CASING GROUP (2 OF 2)
Part of 815509 and 815510 Front and Rear Axle Groups (RT100)

AXLES AND BRAKES



NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	3T0849	4	CAP SCREW
M	2	6V6889	2	NUT
	3	8Q2143	2	LEVER
	4	8Q2147	8	SPACER
	5	8Q2148	8	SPRING
	6	8Q2149	8	PISTON
	7	8Q2150	4	PUSHER
	8	8Q2445	10	BRAKE DISC
	9	8Q2446	10	INTERMEDIATE BRAKE DISC
M	10	975154	2	BOLT
	11	975155	2	SPACER
M	12	975157	4	CYLINDER BOLT
	13	975158	2	FLANGE
	14	975159	2	SPACER
	15	975160	2	O. RING
	16	975161	2	PLUG
	17	975162	2	EXHAUSTING BOLT
	18	975164	6	PIN
	19	975167	2	SPACER
	20	975168	1	BRAKE LEVER
	21	975169	2	PLUG
	22	975170	1	BRAKE LEVER
	23	975172	16	CUP SPRING
	24	975173	8	CIRCLIP
	25	975174	8	RING
	26	975175	8	RING - O
M	27	975178	2	GRUB SCREW
	28	975180	2	SUPPORT

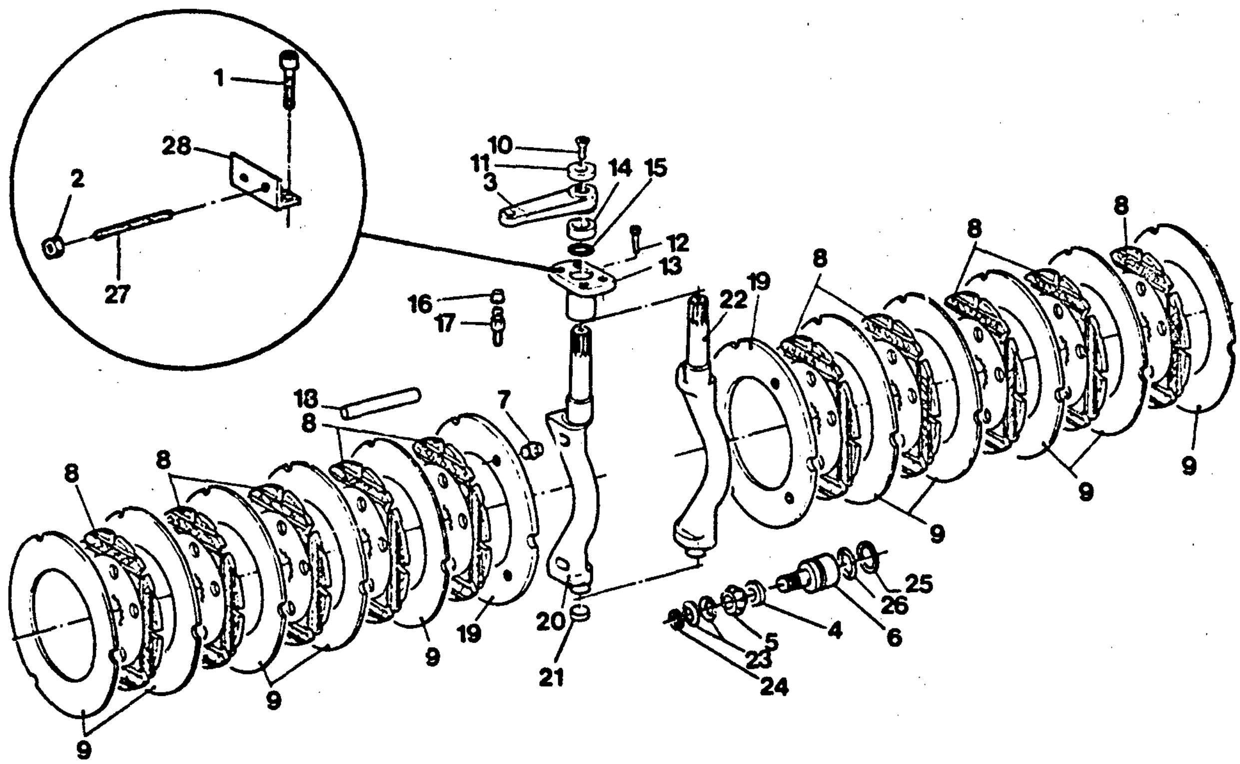
M - METRIC PART

P8Q2447

REV 000

8Q2447 DISC BRAKE GROUP
Part of 986040 Front Axle Group (RT80)

AXLES AND BRAKES



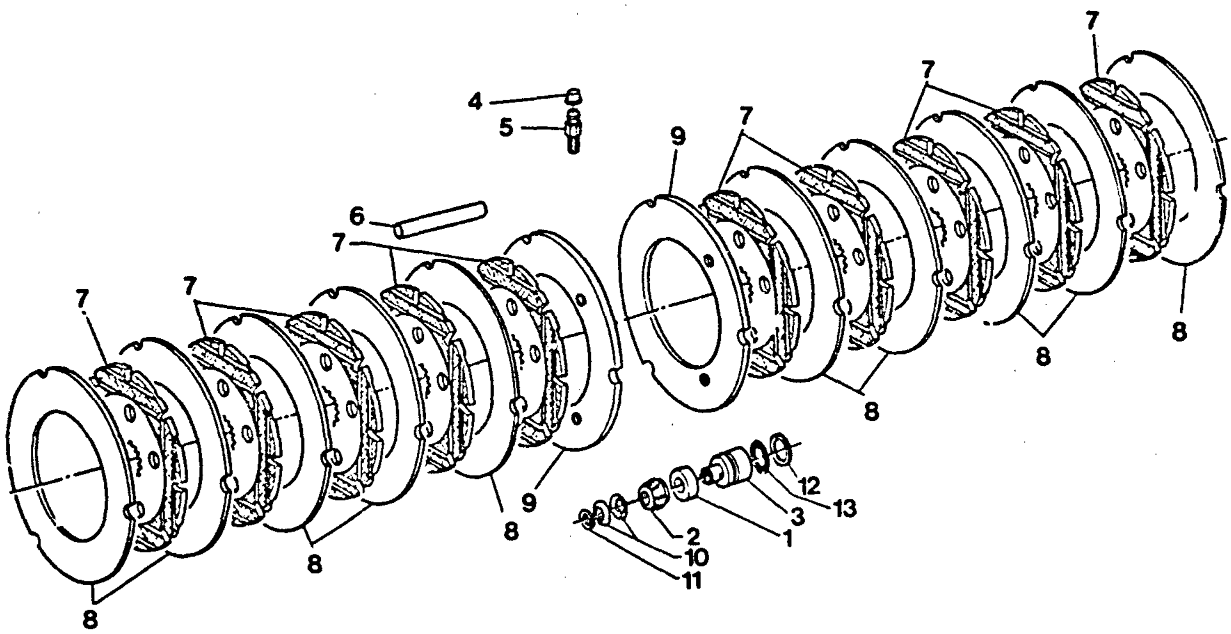
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	3T0849	4	CAP SCREW		15	975160	2	O. RING
M	2	6V6889	2	NUT		16	975161	2	PLUG
	3	8Q2143	2	LEVER		17	975162	2	EXHAUSTING BOLT
	4	8Q2147	8	SPACER		18	975164	6	PIN
	5	8Q2148	8	SPRING		19	975167	2	SPACER
	6	8Q2149	8	PISTON		20	975168	1	BRAKE LEVER
	7	8Q2150	4	PUSHER		21	975169	2	PLUG
	8	975165	10	BRAKE DISC		22	975170	1	BRAKE LEVER
	9	975166	10	INTERMEDIATE BRAKE DISC		23	975172	16	CUP SPRING
M	10	975154	2	BOLT		24	975173	8	CIRCLIP
	11	975155	2	SPACER		25	975174	8	RING
M	12	975157	4	CYLINDER BOLT		26	975175	8	O. RING
	13	975158	2	FLANGE	M	27	975178	2	GRUB SCREW
	14	975159	2	SPACER		28	975180	2	SUPPORT

M - METRIC PART

P8Q2146

REV 000

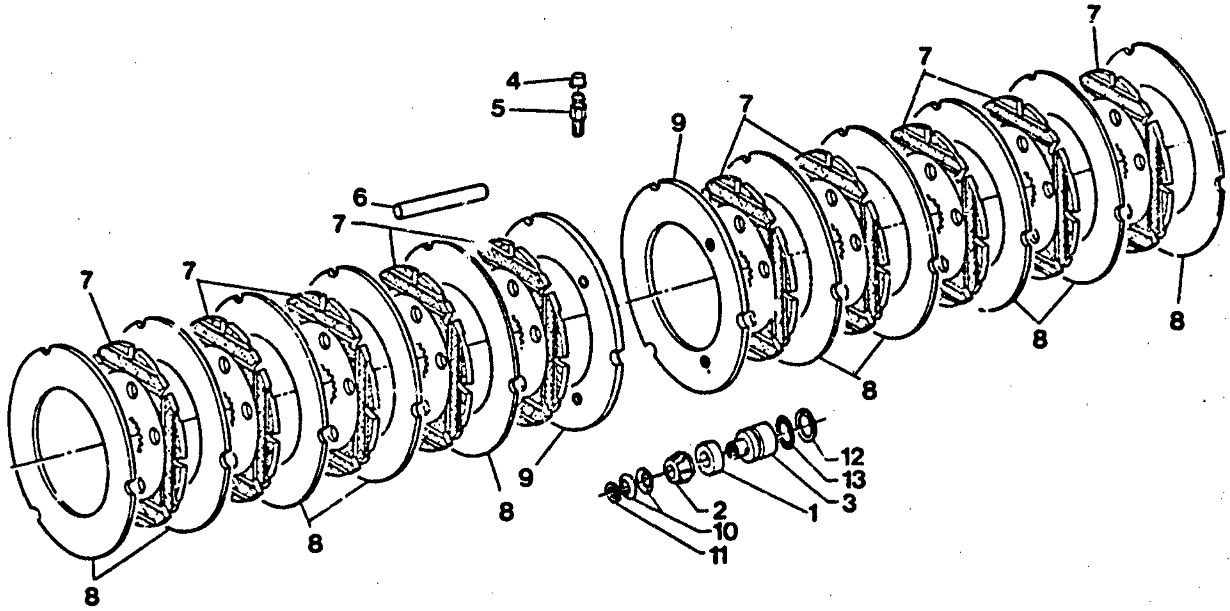
8Q2146 DISC BRAKE GROUP
Part of 815509 Front Axle Group (RT100)



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	8Q2147	8	SPACER		8	8Q2446	10	INTERMEDIATE DISK BRAKE
	2	8Q2148	8	SPRING		9	975167	2	SPACER
	3	8Q2149	8	PISTON		10	975172	16	CUP SPRING
	4	975161	2	PLUG		11	975173	8	CIRCLIP
	5	975162	2	EXHAUSTING BOLT		12	975174	8	RING
	6	975164	6	PIN		13	975175	8	RING - O
	7	8Q2445	10	DISK BRAKE					

P8Q2448
REV 000

8Q2448 DISC BRAKE GROUP (REAR AXLE RT80)
Part of 986041 Rear Axle (RT80)



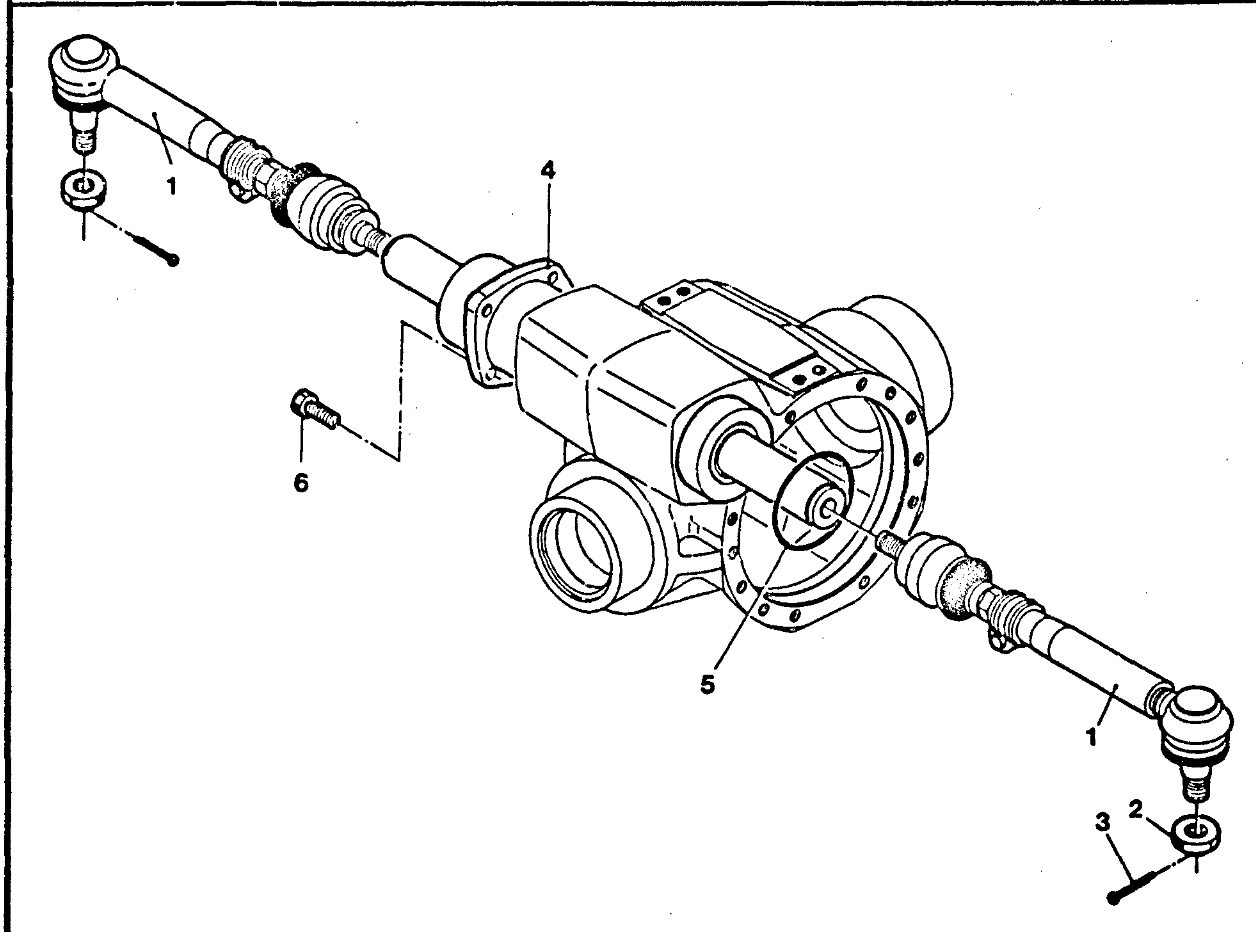
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	8Q2147	8	SPACER		8	975166	10	INTERMEDIATE DISK BRAKE
	2	8Q2148	8	SPRING		9	975167	2	SPACER
	3	8Q2149	8	PISTON		10	975172	16	CUP SPRING
	4	975161	2	PLUG		11	975173	8	CIRCLIP
	5	975162	2	EXHAUSTING BOLT		12	975174	8	RING
	6	975164	6	FIN		13	975175	8	RING - O
	7	975165	10	DISK BRAKE					

P8Q2400

REV 000

8Q2400 DISC BRAKE GROUP (REAR AXLE RT100)
Part of 815510 Rear Axle (RT100)

AXLES AND BRAKES



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	975136	2	TIE ROD					
	2	NSS	2	NUT					
	3	NSS	2	COTTER PIN					
	4	975137	1	CYLINDER ASSEMBLY , INCLUDING;-					
F	–	985857	1	SEAL KIT					
	5	975138	1	O RING					
	6	8T2503	5	BOLT					

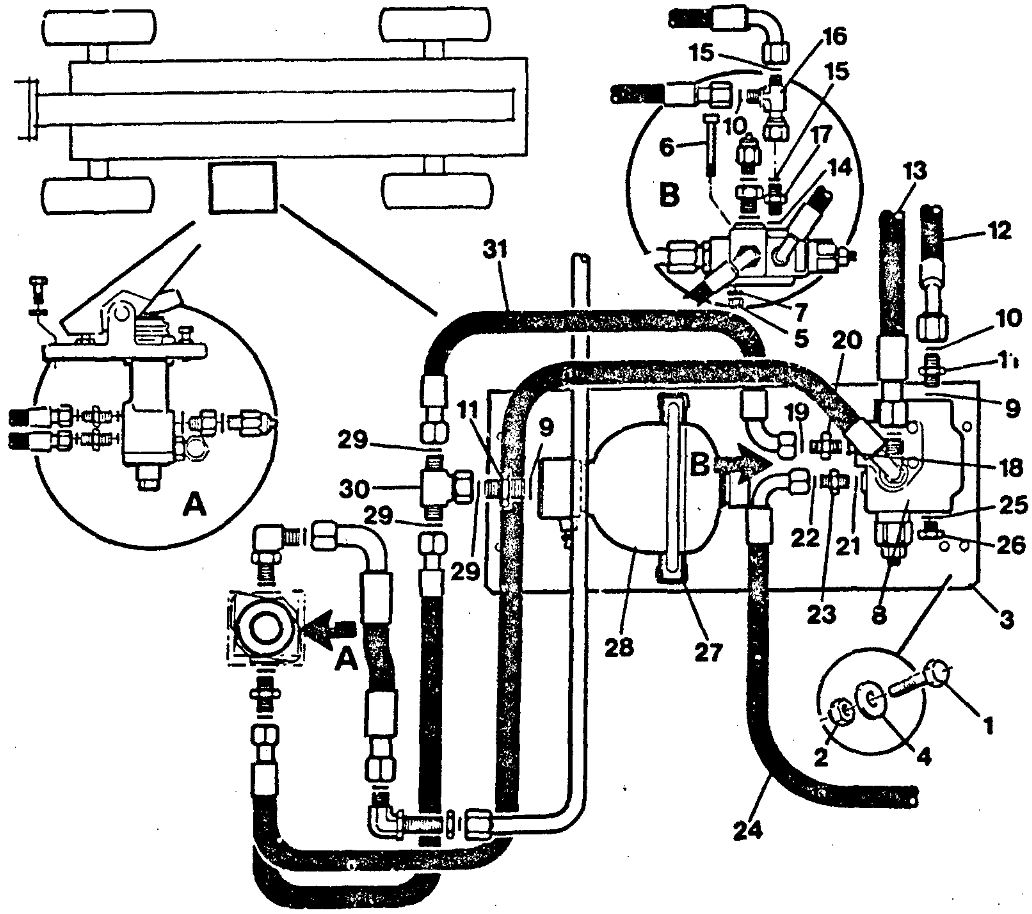
F - NOT SHOWN
NSS - NOT SERVICED SEPARATLY

P975135
9 / 5 / 88

975135 STEERING ROD GROUP

Part of 986040, 815509, 986041 And 815510 Axle Groups

AXLES AND BRAKES



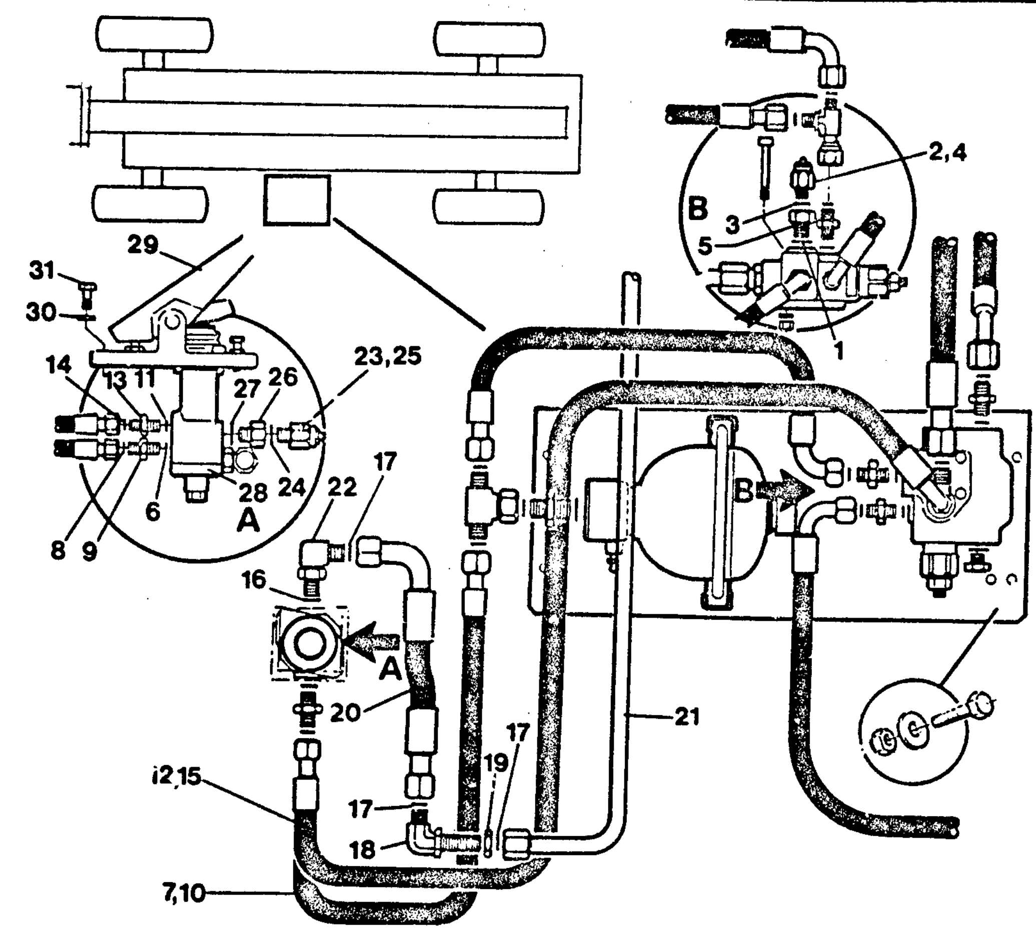
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V7357	4	BOLT		17	6V9872	1	ADAPTOR
M	2	6V7743	4	NUT		18	3K0360	1	O RING O.R.B
	3	8Q2419	1	VALVE PLATE		19	6V8397	1	O RING O.R.F.S
M	4	8T4205	4	WASHER		20	6V8634	1	ADAPTOR
M	5	6V7743	2	NUT		21	3J7354	1	O RING O.R.B
M	6	8T2922	2	SKT HD CAP		22	4J5477	1	O RING O.R.F.S
M	7	8T4205	2	WASHER		23	6V8647	1	ADAPTOR
	8	9T3682	1	ACCUMULATOR CHARGING VALVE		24	8Q2466	1	HOSE AS
	9	3K0360	2	O RING O.R.B		25	3K0360	1	O-RING O.R.B
	10	6V8397	2	O RING O.R.F.S		26	9S4185	1	PLUG
	11	6V8634	2	ADAPTOR		27	6U5219	1	CLAMP
	12	8Q2468	1	HOSE AS		28	8Q2696	1	ACCUMULATOR AS
	13	8Q2492	1	HOSE AS		29	6V8397	3	O RING O.R.F.S
	14	3J7354	1	O RING O.R.B		30	6V9843	1	TEE
	15	6V8397	2	O RING O.R.F.S		31	8Q2464	1	HOSE AS
	16	6V9836	1	TEE					

M - METRIC PART

P8Q2495 Y

REV 000

8Q2495 BRAKE VALVE HYDRAULIC GROUP (1 OF 3)

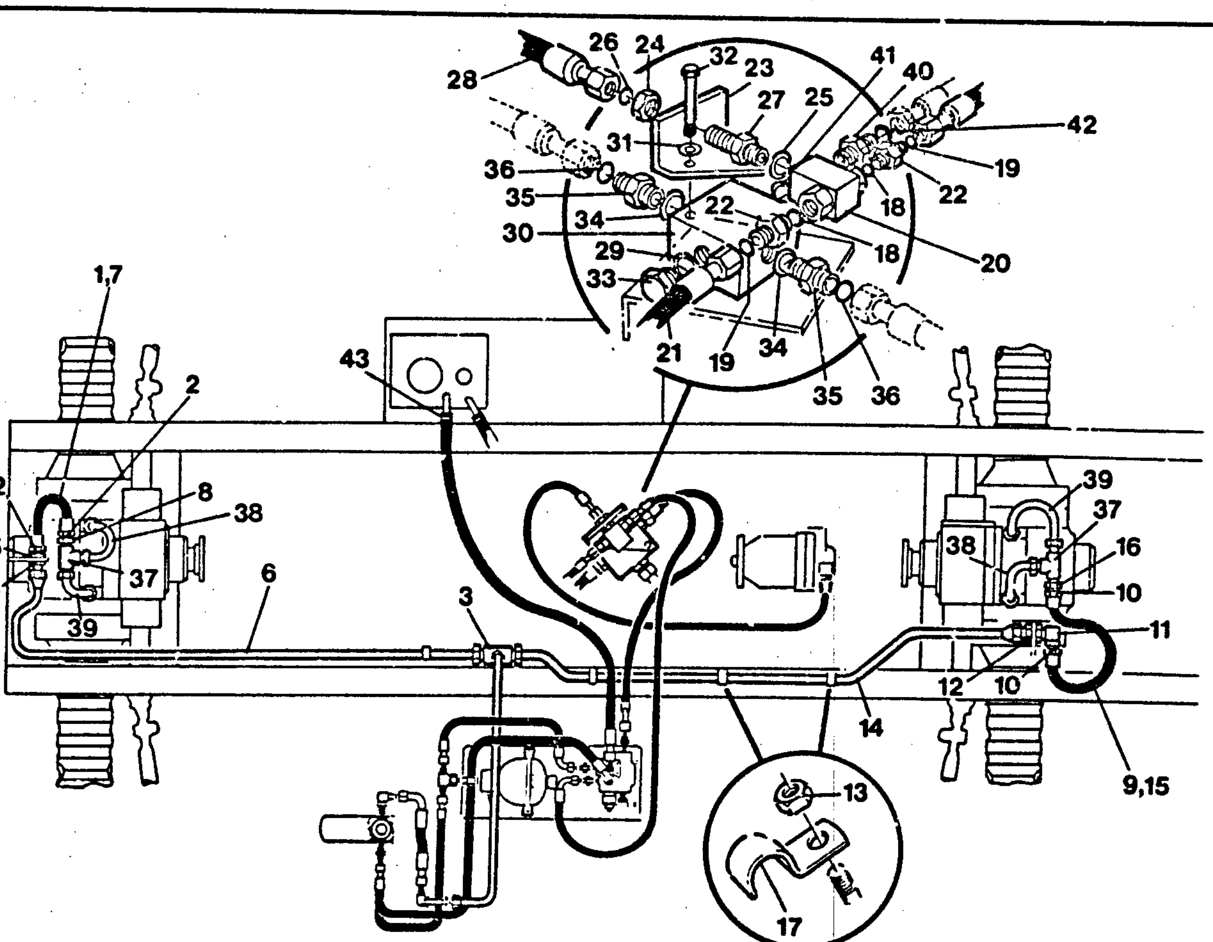


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3K0360	1	O RING O.R.B
	2	5U3685	1	BOOT
M	3	6V9028	1	SEAL
	4	7U9037	1	PRESSURE SWITCH
	5	8Q2483	1	ADAPTOR
	6	3J1907	1	O RING O.R.B
D	7	6R9348	0.25	HOSE PROTECTION
	8	6V8397	1	O RING O.R.F.S
	9	6V8636	1	ADAPTOR
	10	8Q2476	1	HOSE AS
	11	3J1907	1	O RING O.R.B
D	12	6R9348	0.25	HOSE PROTECTION
	13	6V8636	1	ADAPTOR
	14	6V8397	1	O RING O.R.F.S
	15	8Q2477	1	HOSE AS
	16	3J1907	1	O RING O.R.B
	17	6V8398	3	O RING O.R.F.S
	18	6V8981	1	BULKHEAD ELBOW
	19	6V9169	1	BULKHEAD NUT
	20	8Q2478	1	HOSE AS
	21	8Q2481	1	BRAKE PIPE - CAB
	22	8T6876	1	ELBOW
	23	5U3685	1	BOOT
M	24	6V9028	1	SEAL
	25	7U9036	1	PRESSURE SWITCH
	26	8Q2482	1	ADAPTOR
M	27	8Q2490	1	WASHER
	28	8Q2438	1	BRAKE VALVE
	29	8Q2487	1	FOOT PEDAL - BRAKE
M	30	8T4224	6	WASHER
M	31	8T7547	6	BOLT

M - METRIC PART
D - ORDER BY THE METER

P8Q2495 Y
REV 000

8Q2495 BRAKE VALVE HYDRAULIC GROUP (2 OF 3)



NOTE	REF NO	PART NUMBER	QTY	PART NAME
D	1	6R9348	0.40	HOSE PROTECTION
	2	6V8398	2	O RING O.R.F.S
	3	6V8789	1	TEE
	4	6V8995	1	BULKHEAD ADAPTOR
	5	6V9169	1	BULKHEAD NUT
	6	8Q2479	1	BRAKE PIPE - FRONT
	7	8Q2498	1	HOSE AS
	8	8Q2499	1	ADAPTOR
D	9	6R9348	0.25	HOSE PHOTECTION
	10	6V8398	2	O RING O.R.F.S
	11	6V3981	1	BULKHEAD ELBOW
	12	6V9169	1	BULKHEAD NUT
M	13	6V9188	5	NUT
	14	8Q2480	1	BRAKE PIPE - REAR
	15	8Q2497	1	HOSE AS
	16	8Q2499	1	ADAPTOR
	17	8Q2691	5	TUBE CLIP
	18	3J1907	2	O RING O.R.B
	19	4J5477	2	O RING O.R.F.S
	20	6R7605	1	SHUTTLE VALVE
	21	6R7662	1	HOSE
	22	6V8641	2	ADAPTOR

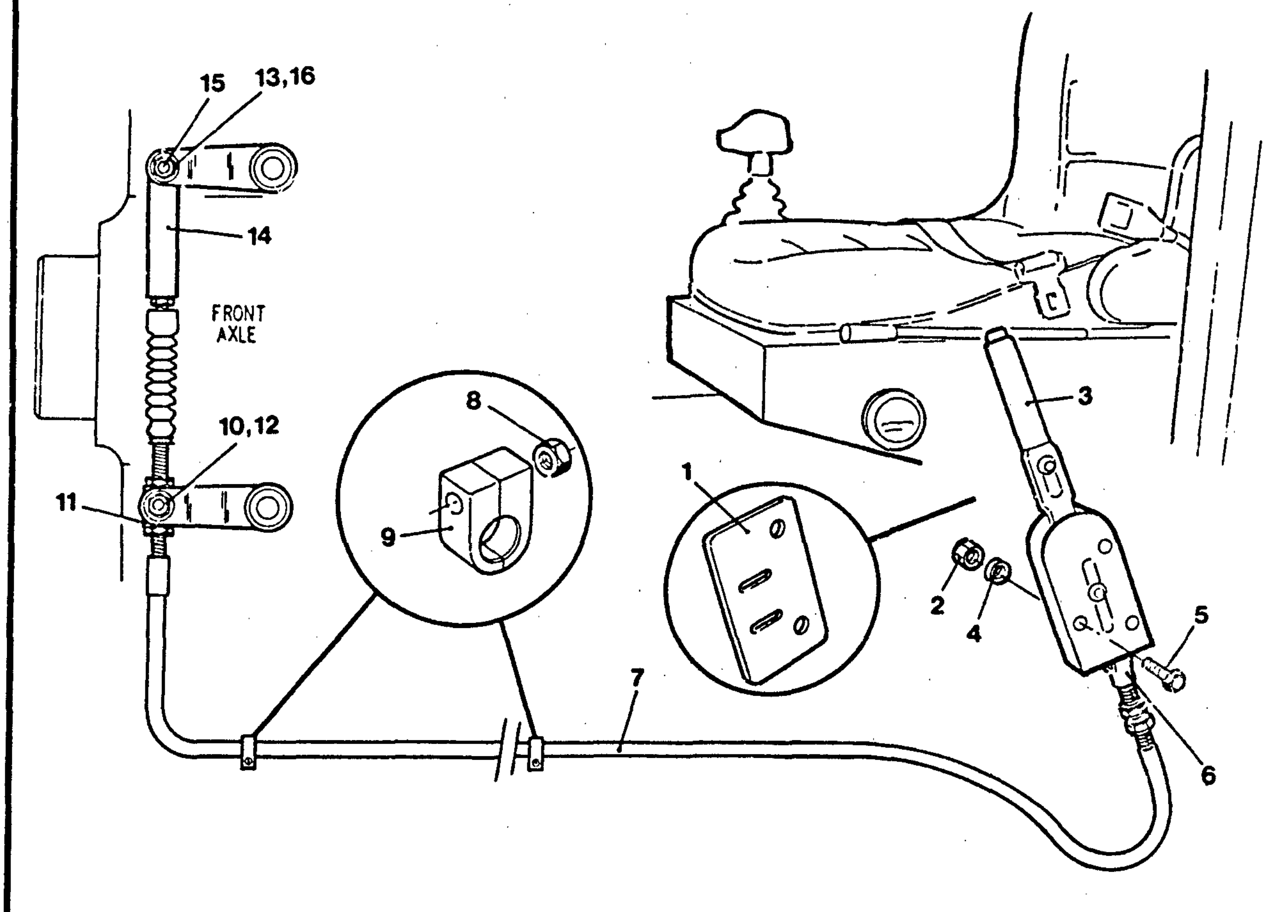
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	23	8Q2661	1	SHUTTLE VALVE HOLDER
	24	2P1279	1	BULKHEAD NUT
	25	3J1907	1	O RING O.R.B
	26	4J5477	1	O RING O.R.F.S
	27	6V8993	1	BULKHEAD ADAPTOR
	28	8Q2654	1	HOSE AS
	29	3D2824	1	O RING O.R.B
	30	8Q2489	1	MANIFOLD
M	31	8T4224	2	WASHER
M	32	8T6370	2	BOLT
	33	9S4183	1	PLUG
	34	3D2824	2	O RING O.R.B
	35	6V8637	2	ADAPTOR
	36	6V9746	2	O RING O.R.F.S
	37	6R9166	2	TEE
	38	6R9197	2	BRAKE PIPE - AXLE
	39	6R9198	2	BRAKE PIPE - AXLE
	40	6V8634	1	ADAPTOR
	41	3K0360	1	O RING O.R.B
	42	6V8397	1	O RING O.R.F.S
	43	8T0154	1	HOSE CLAMP

M - METRIC PART
D - ORDER BY THE METER

P8Q2495 Y
REV 000

8Q2495 BRAKE VALVE HYDRAULIC GROUP (3 OF 3)

MEMORANDUM



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7567	1	BRACKET		9	985122	2	CABLE CLEAT
M	2	6V9189	3	NYLOC NUT	M	10	6V7687	2	SELF LOCKING NUT
	3	816096	1	HANDBRAKE		11	816098	1	PIVOT
M	4	8T4224	3	WASHER	M	12	8T4223	1	WASHER
M	5	8T6912	3	BOLT	M	13	6V7687	1	NYLOC NUT
	6	985103	1	CLEVIS		14	816099	1	EXTENSION
	7	815854	1	CABLE		15	816100	1	PIN
M	8	6V7743	2	NYLOC NUT	M	16	8T4223	1	WASHER

M - METRIC PART

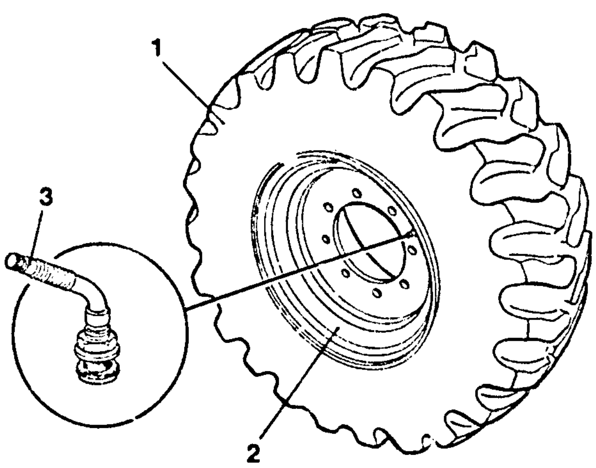
P838456

REV 001

838456 PARKING BRAKE GROUP

Part of 6R7740 Open Cab Group

AXLES AND BRAKES



6R9087 R.H. WHEEL GROUP (RT80)

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	838551	1	TIRE
	2	898020	1	WHEEL
	3	898046	1	VALVE
	F	6R7877	B	HYDRO-FILL

P6R9087 Y

REV 000

6R9088 L.H. WHEEL GROUP (RT80)

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	838551	1	TIRE
	2	898020	1	WHEEL
	3	898046	1	VALVE
	F	6R7877	B	HYDRO-FILL

F - NOT SHOWN

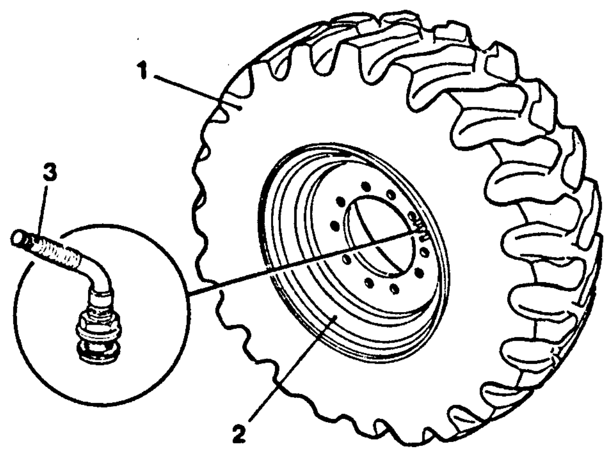
B - USE AS REQUIRED

P6R9088 Y

REV 000

6R9087 AND 6R9088 WHEEL GROUPS (RT80)

AXLES AND BRAKES



815512 R.H. WHEEL GROUP (RT100)

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815405	1	TIRE
	2	898025	1	WHEEL
	3	838917	1	VALVE
	F	838918	B	HYDRO-FILL

P815512 Y
REV 002

815513 L.H. WHEEL GROUP (RT100)

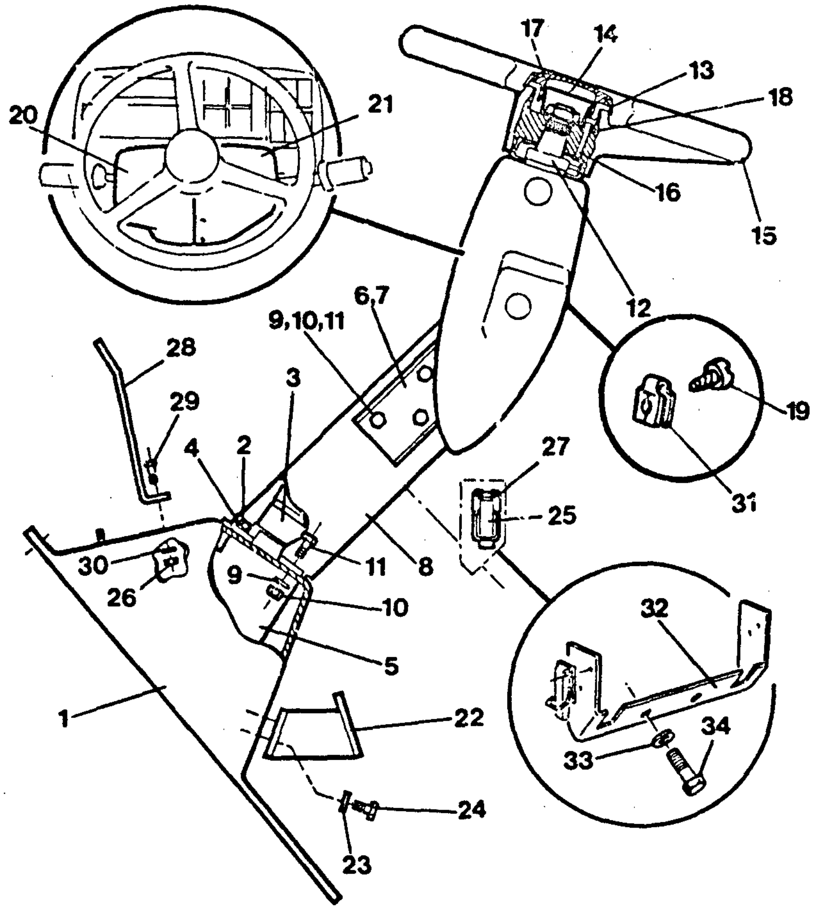
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815405	1	TIRE
	2	898025	1	WHEEL
	3	838917	1	VALVE
	F	838918	B	HYDRO-FILL

F - NOT SHOWN
B - USE AS REQUIRED

P815513 Y
REV 002

815512 AND 815513 WHEEL GROUPS (RT100)

STEERING SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	8Q2082	1	PLATE AS
M	2	4L9337	4	BOLT
	3	844076	1	STEERING ADAPTOR
M	4	8T4121	4	WASHER
Y	5	9T8012	1	STEERING VALVE
	6	844069	1	PIVOT BRACKET L.H.
	7	844070	1	PIVOT BRACKET R.H.
	8	8Q2713	1	MOUNTING BRACKET AS
M	9	8T4121	10	WASHER
M	10	8T4133	10	NUT
M	11	8T4136	10	BOLT
Y	12	844079	1	STEERING COLUMN AS
	13	919071	1	SEAL
	14	923189	1	CUP
	15	923200	1	STEERING WHEEL
	16	987466	3	PIN

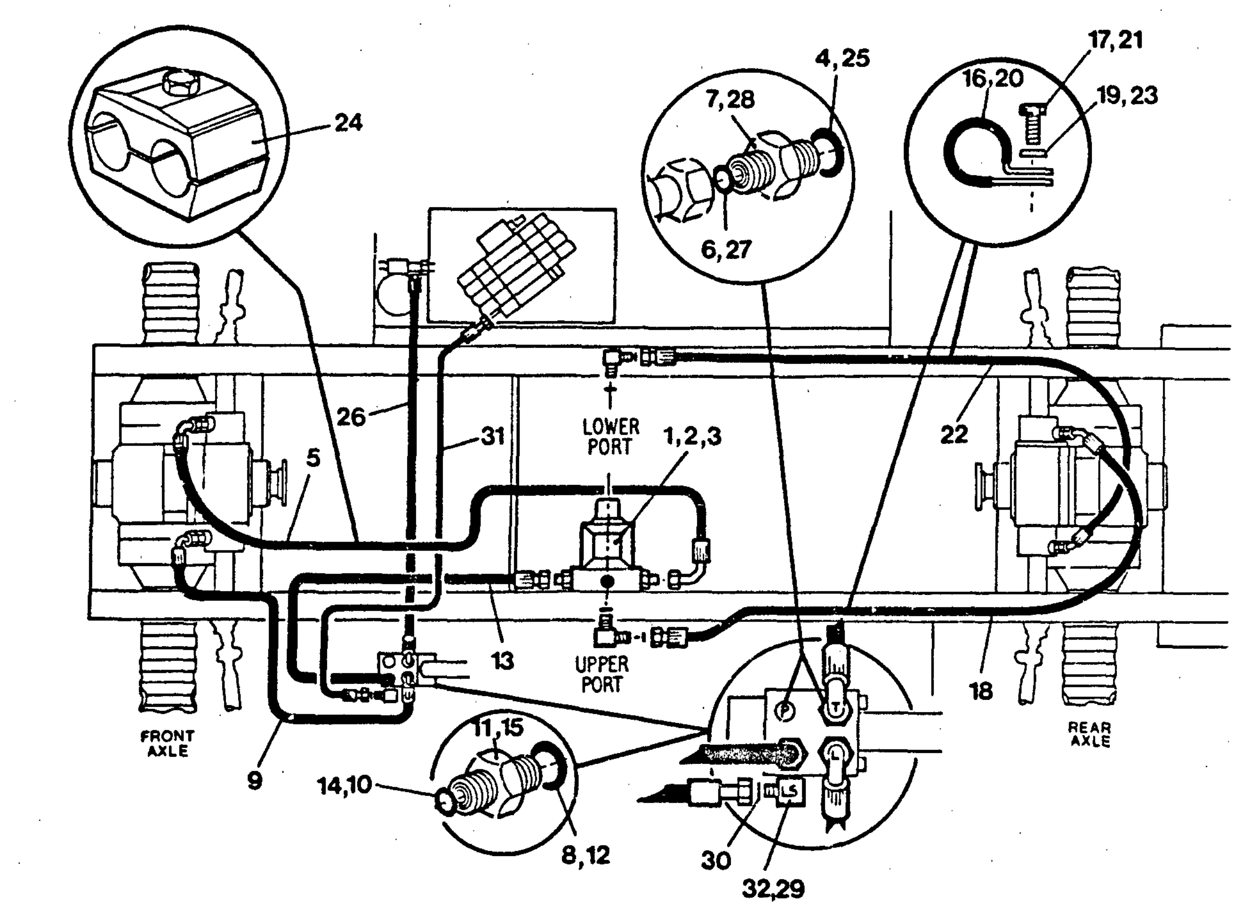
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	17	987467	1	BUTTON
	18	987468	3	SPRING
	19	6R7921	4	SCREW
	20	844080	1	STEERING CANOPY L.H.
	21	844081	1	STEERING CANOPY R.H.
Y	F	6R9018	1	ELEC GROUP STEER COL.
	22	8Q2418	1	SUPPORT AS
M	23	8T4121	2	WASHER
M	24	8T4136	2	BOLT
	25	6R9239	2	LATCH
M	26	6V7743	2	NUT SELF LOCKING
	27	838603	4	RIVET
	28	844262	1	SUPPORT BRACKET
M	29	8T4138	2	BOLT
M	30	8T4205	2	WASHER
	31	8Q2765	4	U. NUT
	32	6R7632	1	BRACKET
M	33	8T4138	2	BOLT
M	34	8T4205	2	WASHER

Y - SEPARATE ILLUSTRATION
M - METRIC PART
F - NOT SHOWN

P8Q2496 Y
REV 002

8Q2496 STEERING CONSOLE GROUP
Part of 6R9019 Cab Group Basic
6R9018 - PAGE 262, 844079 - PAGE 145, 9T8012 - PAGE 144

STEERING SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V7699	4	WASHER	M	17	5C9553	1	BOLT
Y	2	815581	1	SELECTOR VALVE GROUP		18	5I0543	1	HOSE A.S.
M	3	8T0352	4	BOLT	M	19	5P4116	1	WASHER
	4	3K0360	1	O RING O.R.B.		20	3U2754	2	CLIP
	5	5I0540	1	HOSE A.S.	M	21	5C9553	2	BOLT
	6	6V8398	1	O RING O.R.F.S.		22	5I0542	1	HOSE A.S.
	7	6V8639	1	ADAPTOR	M	23	5P4116	2	WASHER
	8	3K0360	1	O RING O.R.B.		24	897726	5	CLAMP
	9	5I0541	1	HOSE A.S.		25	3K0360	1	O RING O.R.B.
	10	6V8397	1	O RING O.R.F.S.		26	6R7663	1	HOSE
	11	6V8634	1	ADAPTOR		27	6V8397	1	O RING O.R.F.S.
	12	3K0360	1	O RING O.R.B.		28	6V8634	1	ADAPTOR
	13	5I0544	1	HOSE A.S.		29	3J7354	1	O RING SEAL O.R.B.
	14	6V8397	1	O RING O.R.F.S.		30	4J5477	1	O RING O.R.F.S.
	15	6V8634	1	ADAPTOR		31	6R7661	1	HOSE
	16	3U2754	1	CLIP		32	6V8628	1	ELBOW

M - METRIC PART
Y - SEPARATE ILLUSTRATION

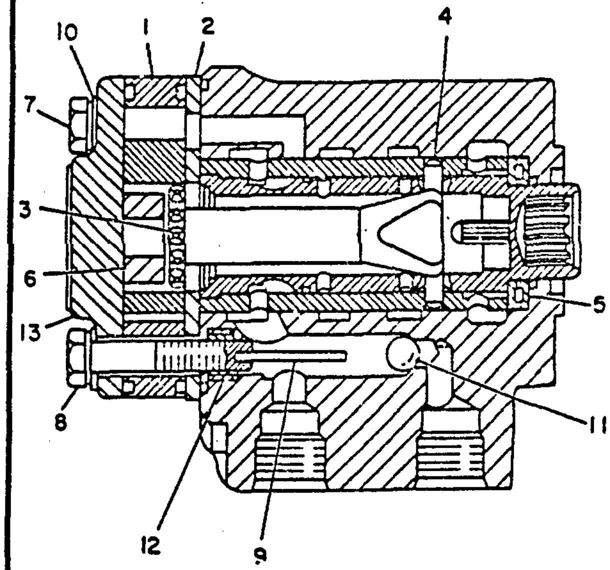
P6R9253
REV 002

6R9253 HYDRAULIC PIPING GROUP - STEERING
815581 - PAGE 144

MEMORANDUM

MEMORANDUM

STEERING SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9T8490	1	GEROTOR
	2	6C0011	1	SPACER
	3	6C0012	1	DRIVE-CONTROL
	4	6C0014	1	PIN
	5	6C0015	1	BEARING
	6	6C0016	1	SPACER
M	7	8T2316	6	BOLT
	8	6C0018	1	BOLT
	9	6C0019	1	PIN-ROLL
	10	6C0020	7	WASHER
	11	6C0021	1	BALL
	12	6C0022	1	BUSHING
	13	6C0023	1	CAP
				THE FOLLOWING REPAIR KIT IS AVAILABLE
		6C0025	1	KIT-SEAL

M-METRIC PART

M-466416

9T8012 PUMP GROUP - METERING (STEERING VALVE)
Part of 8Q2496 Steering Console Group

STEERING SYSTEM

ITEM	PART NO.	QTY	DESCRIPTION
F	3K0360	4	O-RING SEAL (3/4ORB)
F	6V8397	4	'O' RING SEAL
F	6V8634	2	ADAPTOR
F	6V8723	2	ELBOW
F	985871	1	SELECTOR VALVE-SOLENOID OPERATED

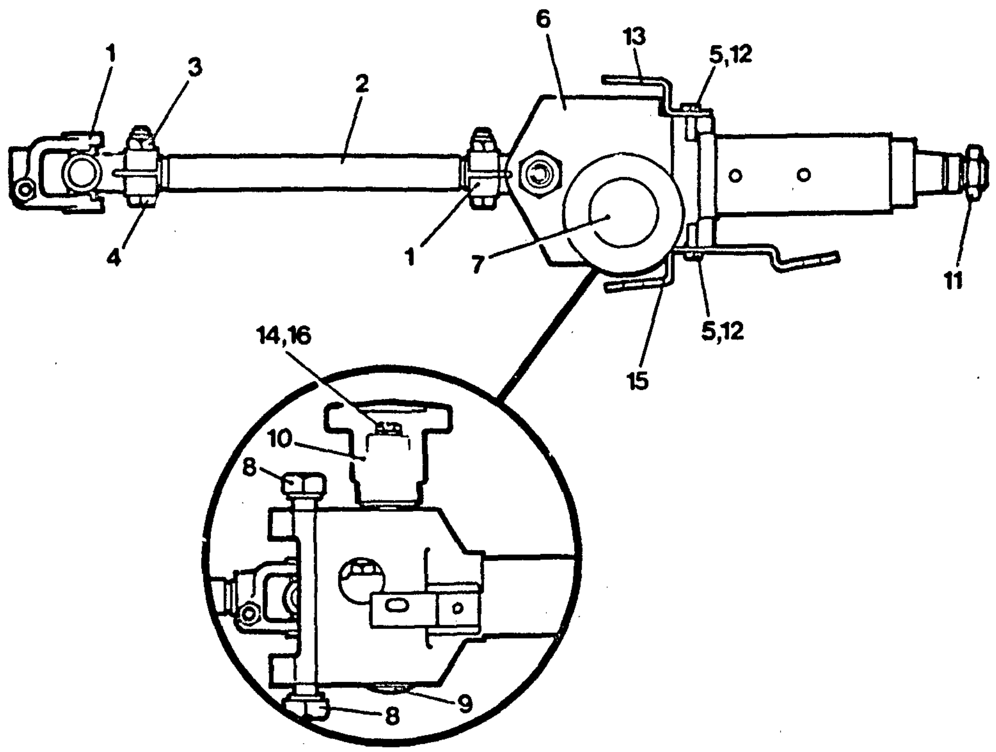
F - NOT SHOWN

P815581

REV002

815581 SELECTOR VALVE GROUP
Part of 6R9253 Hydraulic Piping - Steering

STEERING SYSTEM



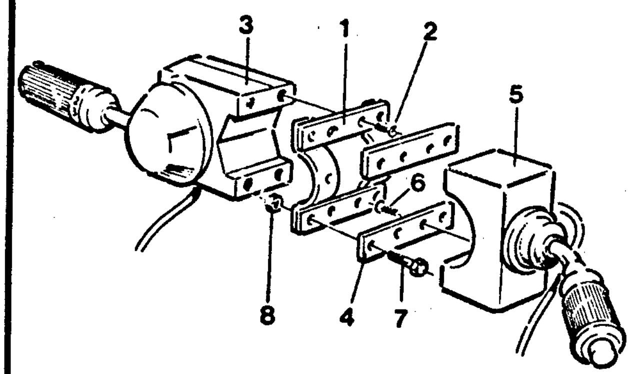
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7551	2	UNIVERSAL JOINT		9	6R7558	1	CLAMP BOLT
	2	6R7552	1	SHAFT		10	6R7559	1	KNOB / CLAMP NUT
M	3	6V9189	4	NYLCC NUT	M	11	6V8227	1	NUT
M	4	7X0818	4	BOLT	M	12	8T4205	2	WASHER
M	5	5C9553	2	BOLT		13	510618	1	CANOPY BRACKET - UPPER
	6	6R7553	1	STEERING COLUMN	M	14	6V7699	1	WASHER
	7	6R7554	1	LOGO		15	844078	1	CANOPY BRACKET - LOWER
	8	6R7557	2	PIVOT BOLT	M	16	8T0288	1	BOLT

M - METRIC PART

P844079 Y
REV 002

844079 STEERING COLUMN GROUP
Part of 8Q2496 Steering Console Group

STEERING SYSTEM



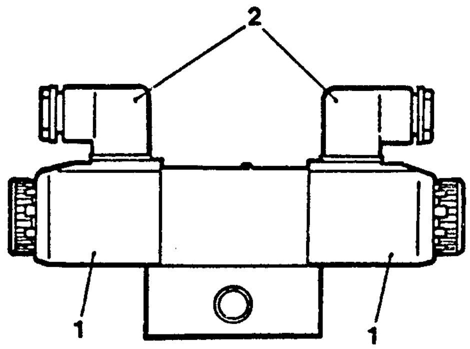
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7570	1	BRACKET AS.
M	2	6R7943	4	SOCKET SCREW
	3	8C5336	1	TRANSMISSION CONTROL
	4	6R7572	2	PLATE - COLUMN SWITCH
	5	6R7916	1	STEERING COLUMN SWITCH
M	6	6R7943	2	SOCKET SCREW
M	7	6V4298	4	BOLT
M	8	6V9188	4	NYLOC NUT

M - METRIC PART

P6R7918 Y
REV 000

6R7918 STEER COLUMN SWITCH GROUP
Part of 838832 and 838834 Road Lighting Groups - Standard Cab
Part of 6R7732 All Weather Cab Group

STEERING SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	985872	2	SOLENOID COIL
	2	816316	2	CONNECTOR
F	–	985873	1	SEAL KIT

F - NOT SHOWN

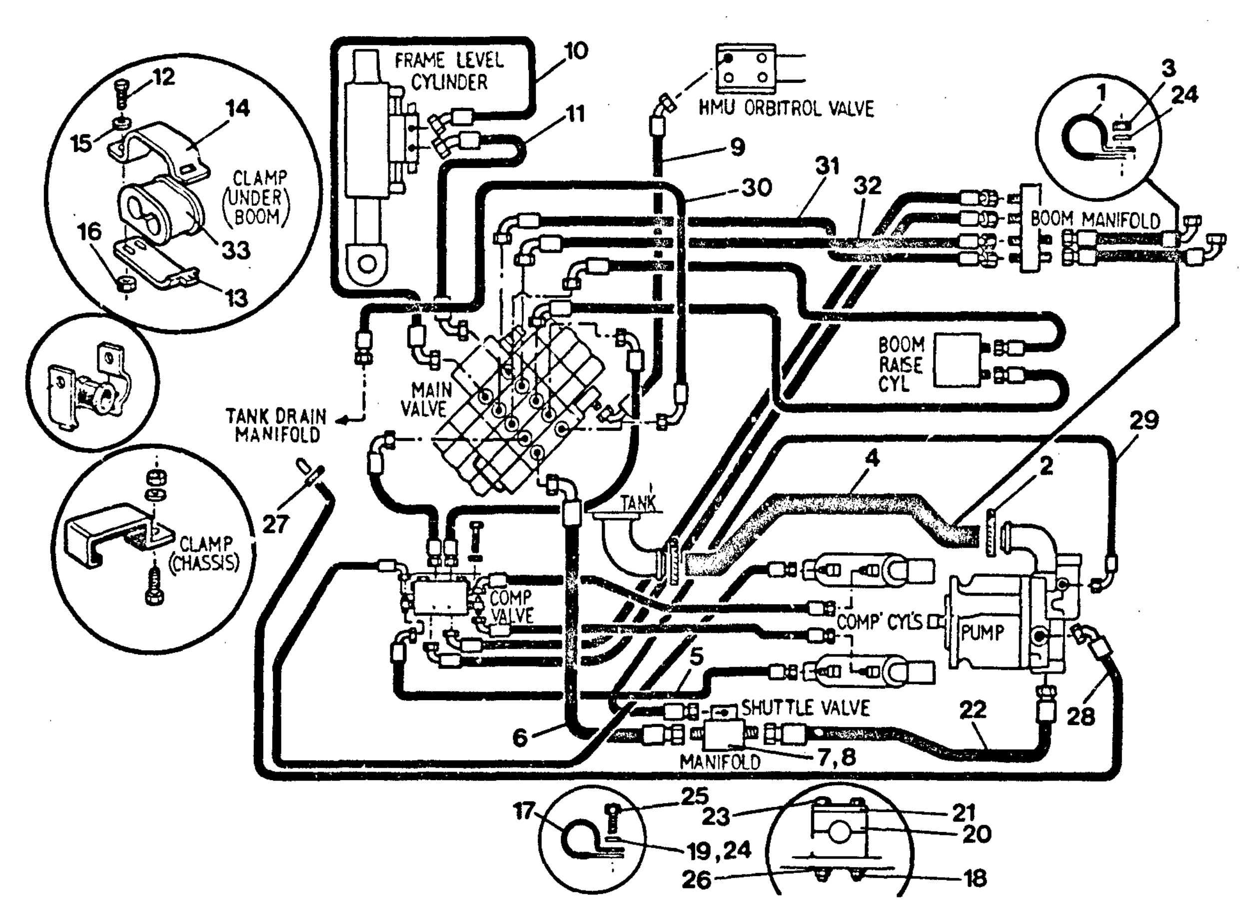
P985871 Y
REV 000

985871 DIRECTIONAL CONTROL VALVE GROUP
Part of 6R9253 Hydraulic Piping - Steering

MEMORANDUM

MEMORANDUM

HYDRAULIC SYSTEM



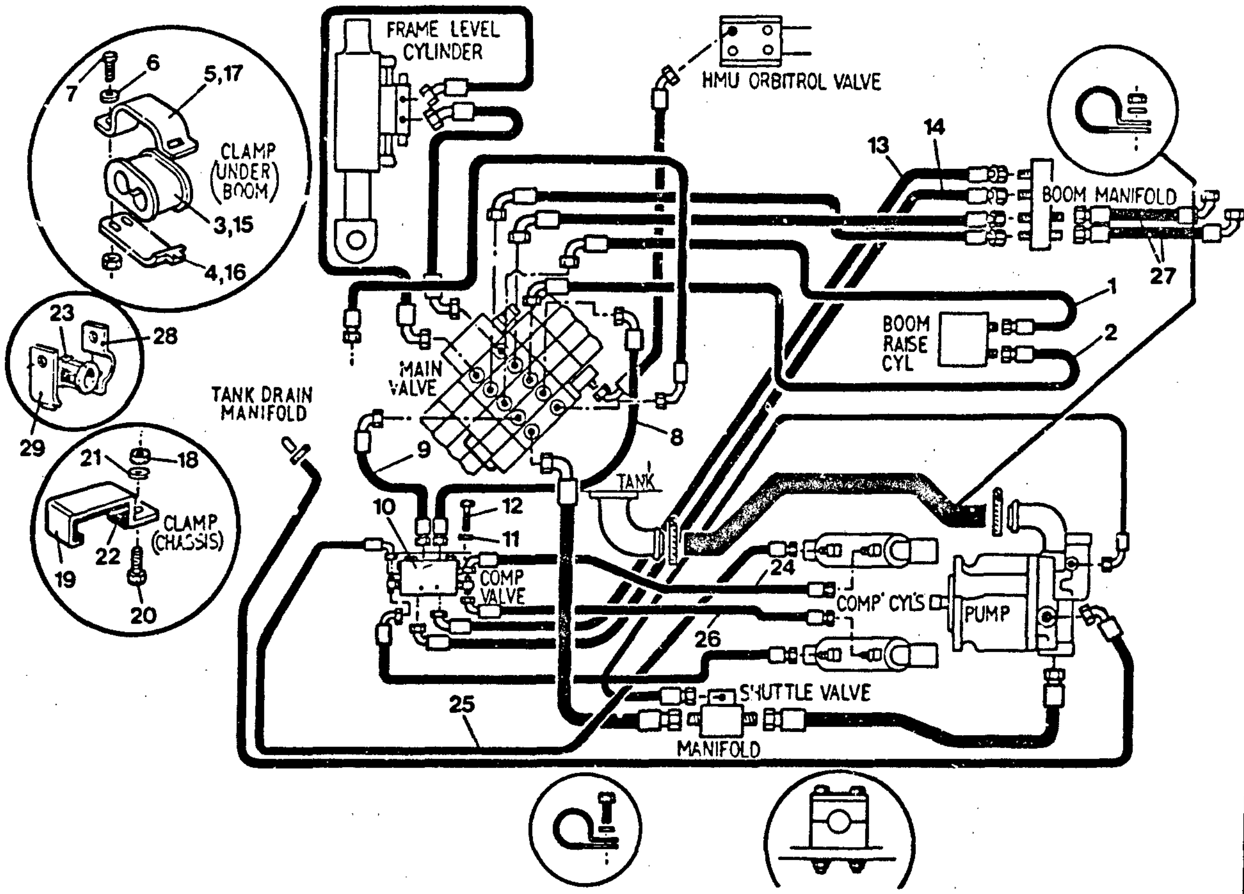
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2U3931	2	P CLIP		21	838438	1	COVER PLATE
	2	5P0597	2	HOSE CLIP		22	6R7669	1	HOSE
M	3	6V7744	2	SELF LOCKING NUT	M	23	8T3844	2	BOLT
	4	8Q2718	1	HOSE	M	24	8T4121	3	WASHER
	5	815588	1	HOSE	M	25	8T4137	1	BOLT
	6	8Q2474	1	HOSE	M	26	8T4205	2	WASHER
	7	4J5477	1	O RING		27	5D1026	1	HOSE CLIP
	8	838564	1	TUBE STOP END		28	6R7664	1	HOSE
	9	6R7665	1	HOSE		29	8Q2654	1	HOSE
	10	5I0547	1	HOSE		30	5I0534	1	HOSE
	11	5I0547	1	HOSE		31	5I0536	1	HOSE
M	12	8T4195	2	BOLT		32	6R7666	1	HOSE
	13	3G8054	1	CLAMP LOWER		33	3G8047	1	GROMMET
	14	3G8057	1	CLAMP UPPER					
M	15	8T4121	2	WASHER					
M	16	8T4133	2	NUT					
	17	2U2749	1	CLIP					
	18	5C2890	2	NUT					
	19	5P4116	1	WASHER					
	20	838431	1	CLAMP BODY					

M - METRIC PART

P6R9252 Y
REV 003

6R9252 HYDRAULIC PIPING GROUP - CHASSIS (1 of 2)

HYDRAULIC SYSTEM



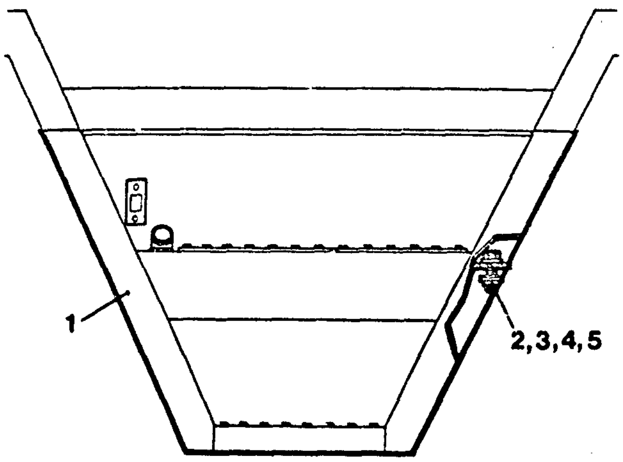
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7567	1	HOSE		16	3G8054	1	CLAMP LOWER
	2	6R7667	1	HOSE		17	3G8057	1	CLAMP UPPER
	3	3G8047	1	GROMMET	M	18	6V9189	1	NYLOC NUT
	4	3G8054	1	CLAMP LOWER		19	838043	1	PIPE CLAMP
	5	3G8057	1	CLAMP UPPER	M	20	8T4189	1	BOLT
M	6	8T4121	2	WASHER	M	21	8T4224	1	WASHER
M	7	8T4137	2	BOLT		22	985707	1	PROTECTION-RUBBER
	8	6R7675	1	HOSE		23	6V1249	1	GROMMET
	9	6R7675	1	HOSE		24	5I0545	1	HOSE
Y	10	844320	1	VALVE GROUP COMP RAMS		25	815587	1	HOSE
M	11	8T4224	2	WASHER		26	5I0546	1	HOSE
M	12	8T4177	2	BOLT		27	838011	2	HOSE
	13	5I0537	1	HOSE		28	5P7464	1	CLAMP
	14	5I0537	1	HOSE		29	5P7465	1	CLAMP
	15	3G8047	1	GROMMET					

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P6R9252 Y
REV 003

6R9252 HYDRAULIC PIPING GROUP - CHASSIS (2 of 2)

HYDRAULIC SYSTEM



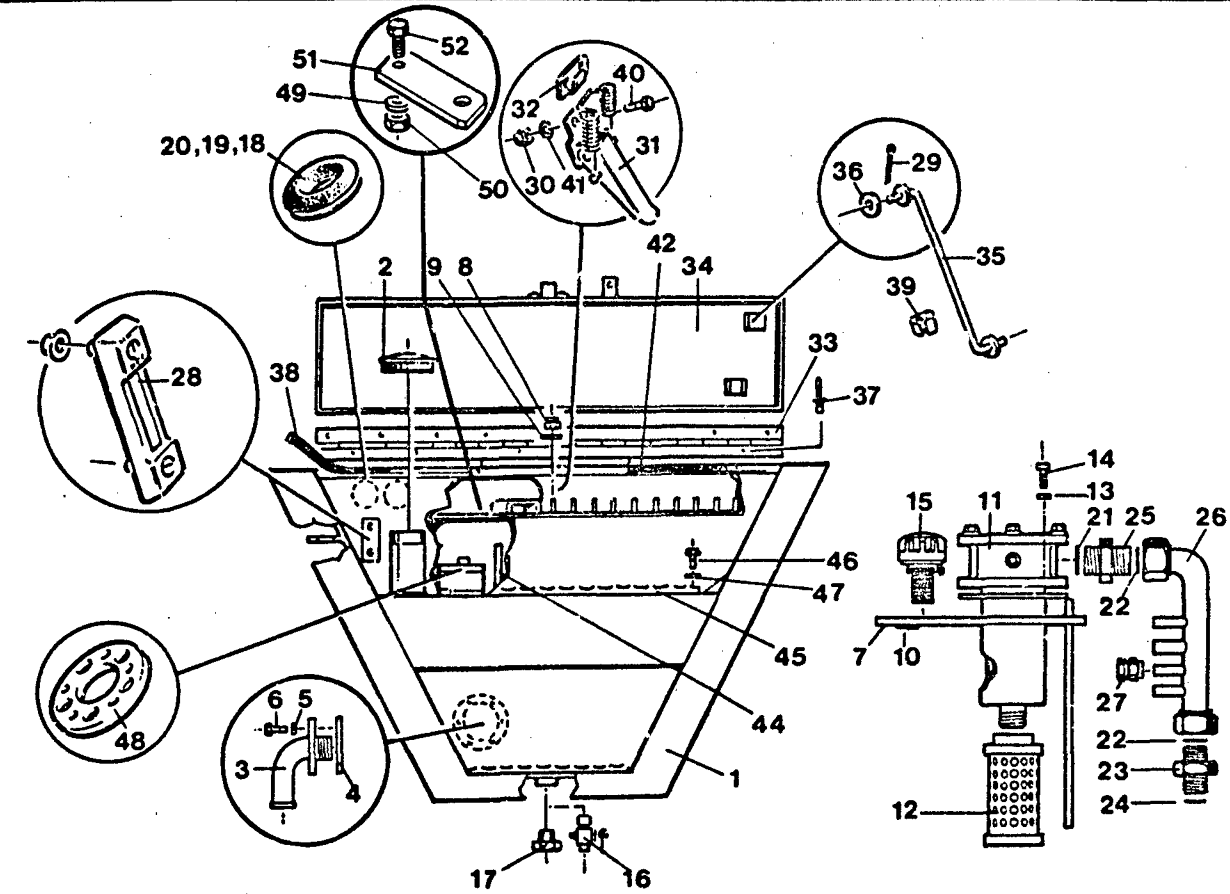
NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	6R7847	1	HYDRAULIC FUEL TANK GROUP
M	2	8T4194	4	BOLT
M	3	8T4223	4	WASHER
M	4	8T4895	4	WASHER
M	5	8T4244	4	NUT SELF LOCKING

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P6R7739 Y
REV 000

6R7739 HYDRAULIC AND FUEL TANK MOUNTING GROUP
6R7847 - PAGE 152

HYDRAULIC SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	844371	1	TANK WELD AS.
	2	510497	1	FUEL CAP
	3	897491	1	FLANGE AS.
	4	897770	1	GASKET
M	5	8T4121	6	WASHER
M	6	8T4137	6	BOLT
	7	6R9039	1	COVER PLATE AS.
M	8	6V7744	28	NUT - SELF LOCKING
M	9	8T4121	28	WASHER
	10	985566	1	GASKET SEALANT
Y	11	837904	1	FILTER AS.
	12	897713	1	DIFFUSER
M	13	8T4121	4	WASHER
M	14	8T4136	4	BOLT
	15	6R77[illegible]7	1	FILLER BREATHER
	16	3B9069	1	COCK DRAIN
	17	5S4017	1	DRAIN PLUG
	18	2U4578	1	GROMMET
	19	3H2900	3	GROMMET
	20	5P8131	1	GROMMET
	21	2S4078	1	O RING SEAL O.R.B
	22	5K9090	2	O. RING SEAL O.R.F.S
	23	6V8740	1	UNION
	24	6V9746	1	O. RING
	25	6V9875	1	ADAPTOR
	26	816156	1	MANIFOLD
	27	838564	1	TUBE STOP END

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	28	6R7565	1	OIL LEVEL GAUGE
	29	3B4609	1	COTTER PIN
M	30	3T0851	4	NUT - SELF LOCKING
	31	3U2004	1	FASTENER
	32	5U5009	1	CATCH PLATE
	33	6R7679	1	HINGE
	34	6R9101	1	TANK COVER AS.
	35	6R9111	1	STAY AS. - TANK LID
M	36	6V7699	1	WASHER
	37	8Q2087	16	RIVET
D	38	815720	.67	GRIP SEAL
	39	816087	1	PLASTIC CLIP
M	40	8T0288	4	BOLT
M	41	8T0328	4	WASHER
D	42	815720	.67	GRIP SEAL
Y	44	6R7604	1	STACK PIPE AS.
	45	844135	1	UPPER TANK STEP
M	46	8T4171	4	BOLT
M	47	8T4205	4	WASHER
A	48	6R9266	1	ADAPTOR (FIRST TYPE TANKS)
M	49	6V5839	2	WASHER
M	50	6V7744	1	NYLOC NUT
	51	8Q2068	1	PLATE
M	52	8T4137	1	BOLT

M - METRIC PART
Y - SEPARATE ILLUSTRATION
D - ORDER BY THE METER
A - NOT PART OF THIS GROUP

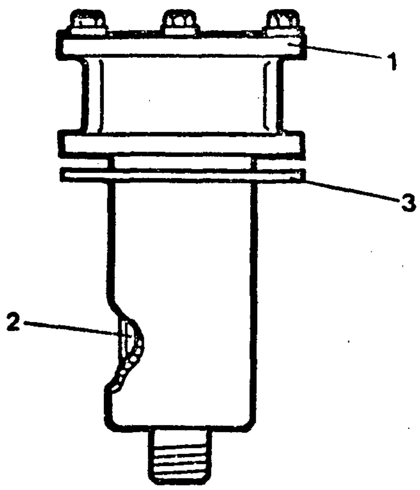
P6R7847 Y
REV 005

6R7847 HYDRAULIC & FUEL TANK GROUP

837904 - PAGE 153, 6R7604 - PAGE 154.

Part of 6R7739 Hydraulic and Fuel Tank Mounting Group.

HYDRAULIC SYSTEM

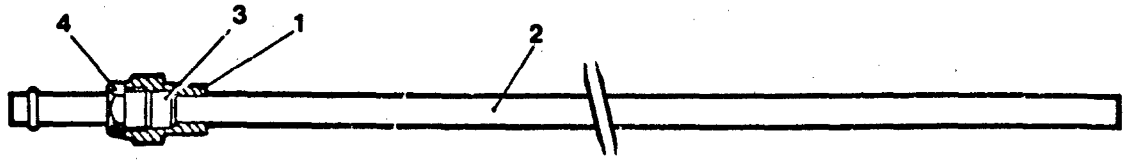


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	837904	1	SEAL KIT
	2	837905	1	ELEMENT
	3	545915	1	GASKET

P837904 Y
REV 000

837904 FILTER GROUP
Part of 6R7647 Hydraulic and Fuel Tank G.P

HYDRAULIC SYSTEM

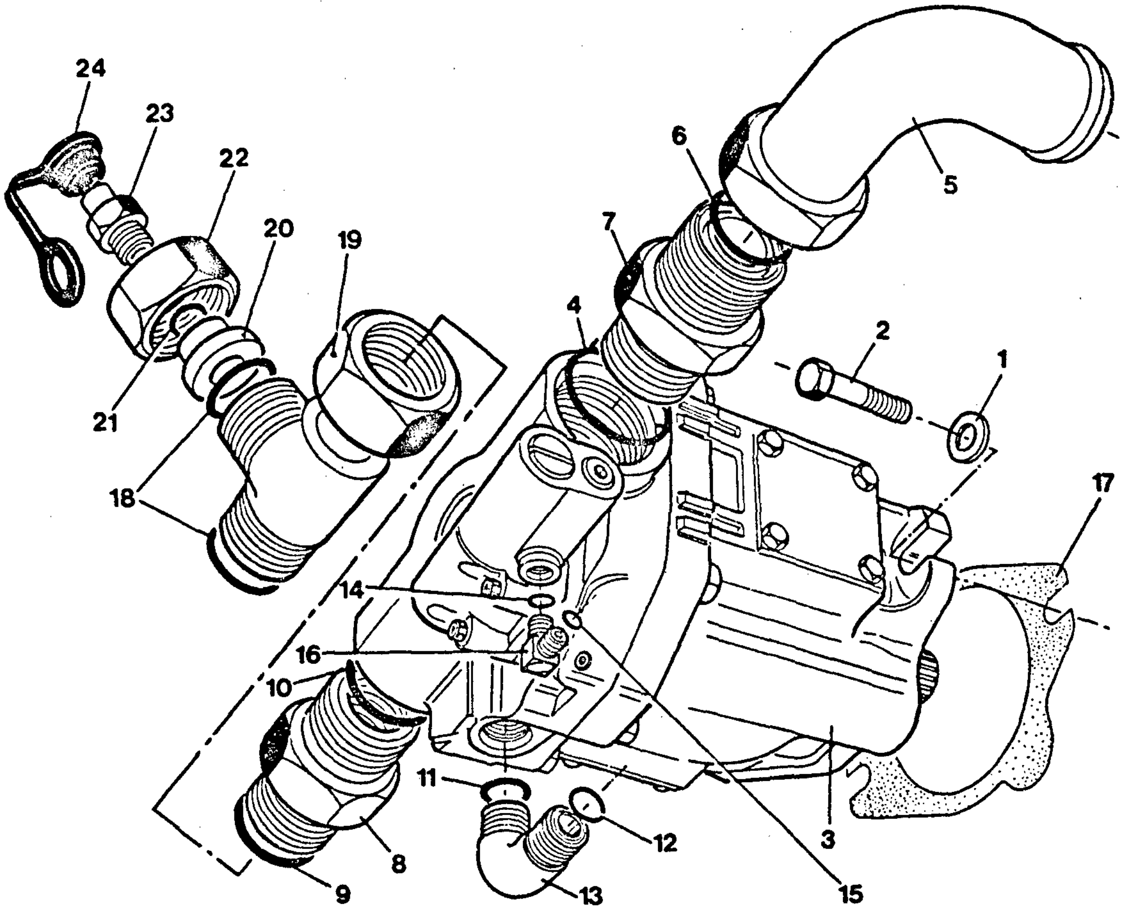


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7602	1	ADAPTOR		3	816118	1	TUBE SLEEVE
	2	6R7603	1	STACK PIPE		4	816119	1	MALE NUT

P6R7604 Y
REV 000

6R7604 STACK PIPE GROUP
Part of 6R7847 Hydraulic and Fuel Tank G.P.

HYDRAULIC SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	8T4223	2	WASHER		13	6V8721	1	ELBOW
M	2	8T4956	2	BOLT		14	3J7354	1	O RING O.R.B.
Y	3	898146	1	PUMP		15	4J5477	1	O RING O.R.F.S.
	4	6K6307	1	O RING O.R.B.		16	6V3628	1	ELBOW
	5	897786	1	ELBOW		17	844104	1	GASKET
	6	8T0315	1	O RING O.R.F.S.		18	6V9746	2	O RING O.R.F.S.
	7	8T7926	1	ADAPTOR		19	6V9839	1	TEE
	8	6V8716	1	ADAPTOR		20	897616	1	ADAPTOR
	9	6V9746	1	O RING O.R.F.S.		21	3J1907	1	O RING O.R.B.
	10	7M8485	1	O RING O.R.B.		22	6V8556	1	FEMALE NUT
	11	2M9780	1	O RING O.R.B.		23	6V3965	1	TEST NIPPLE
	12	6V8398	1	O RING O.R.F.S.		24	6V0852	1	COVER

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P815514 Y
REV 004

815514 HYDRAULIC PUMP GROUP
Part of 837968 Transmission Group

MEMORANDUM

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HYDRAULIC SYSTEM

NOTE	ITEM	PART NO.	QTY	DESCRIPTION
	F	5M3062	3	BOLT HX HD 3/8UNC*3/4LG GR S
	F	844313	1	HUSCO 4 SPOOL VALVE(ALL ELECTRIC)
M	F	8T4121	3	WASHER HD.M10(ZINC PLATED)
	F	838544	1	BRACKET-VALVE MOUNTING
	F	898033	1	VALVE MOUNTING BRACKET
M	F	8T4179	4	BOLT HX HD 12X20 (8.8) Z/P
M	F	8T4223	4	WASHER HD.M12(ZINC PLATED)
	F	2M9780	1	'O' RING
	F	6V8629	1	ELBOW
	F	6V9746	1	'O' RING
	F	2M9780	1	'O' RING
	F	6V8629	1	ELBOW
	F	6V9746	1	'O' RING
	F	3K0360	6	O-RING SEAL(3/4ORB)
	F	6R9165	3	ADAPTOR STR THD (LONG)
	F	6V8398	6	O-RING SEAL(13/16ORFS)
	F	6V8639	3	ADAPTOR
	F	3K0360	2	O-RING SEAL(3/4ORB)
	F	4J5477	2	O-RING SEAL (9/16ORFS)
	F	6V8397	2	'O' RING SEAL
	F	6V8634	2	ADAPTOR
	F	6V8934	2	REDUCER11/16-16ORFS
	F	4J5477	1	O-RING SEAL (9/16ORFS)
	F	7J0204	1	O-RING SEAL3/8ORB
	F	815622	1	ADAPTOR3/8-24ORBX9/16-18ORFS
	F	3J1907	1	'O' RING SEAL
	F	4J5477	2	O-RING SEAL (9/16ORFS)
	F	6V8641	1	ADAPTOR
	F	6V9849	1	ELBOW 9/16-18ORFSX9/16-18ORFS(
	F	3J1907	2	'O' RING SEAL
	F	6V0852	1	COVER TEST POINT
	F	6V3965	1	NIPPLE ASSY QUICK RELEASE
	F	6V8398	2	O-RING SEAL(13/16ORFS)
	F	6V9873	1	ADAPTOR9/16-18ORBX13/16-16ORFS
	F	815645	1	TEE FEMALE ORFS
	F	3J1907	1	'O' RING SEAL
	F	6V0852	1	COVER TEST POINT
	F	6V3965	1	NIPPLE ASSY QUICK RELEASE
	F	3J1907	2	'O' RING SEAL
	F	4J5477	1	O-RING SEAL (9/16ORFS)

F - NOT SHOWN
M - METRIC PART

P6R9255
REV000

6R9255 HYD VALVE GROUP (4 SPOOL)

MEMORANDUM

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MEMORANDUM

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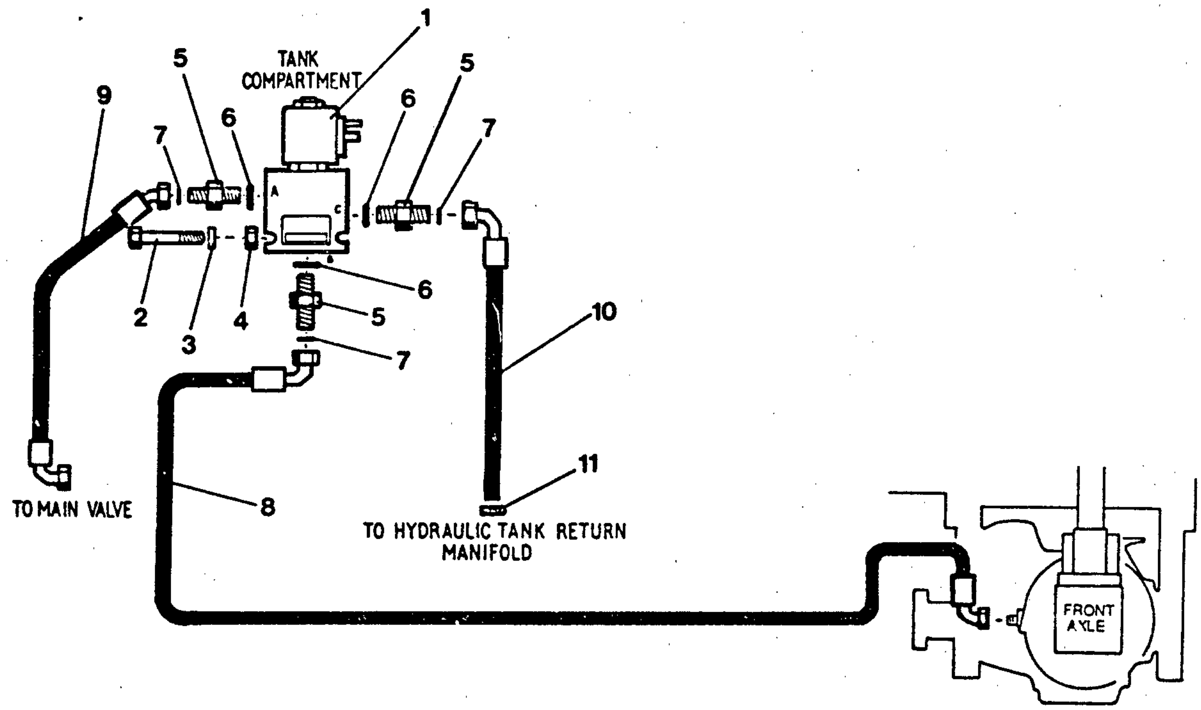
HYDRAULIC SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	985093	1	SOLENOID VALVE		6	3J1907	3	O RING O.R.B.
M	2	7X2534	2	BOLT		7	4J5477	3	O RING O.R.F.S.
M	3	8T4205	4	WASHER		8	6R7674	1	HOSE
M	4	6V7743	2	NUT SELF LOCKING		9	5I0549	1	HOSE
	5	6V8641	3	ADAPTOR		10	5I0548	1	HOSE
						11	1P4278	1	CLAMP

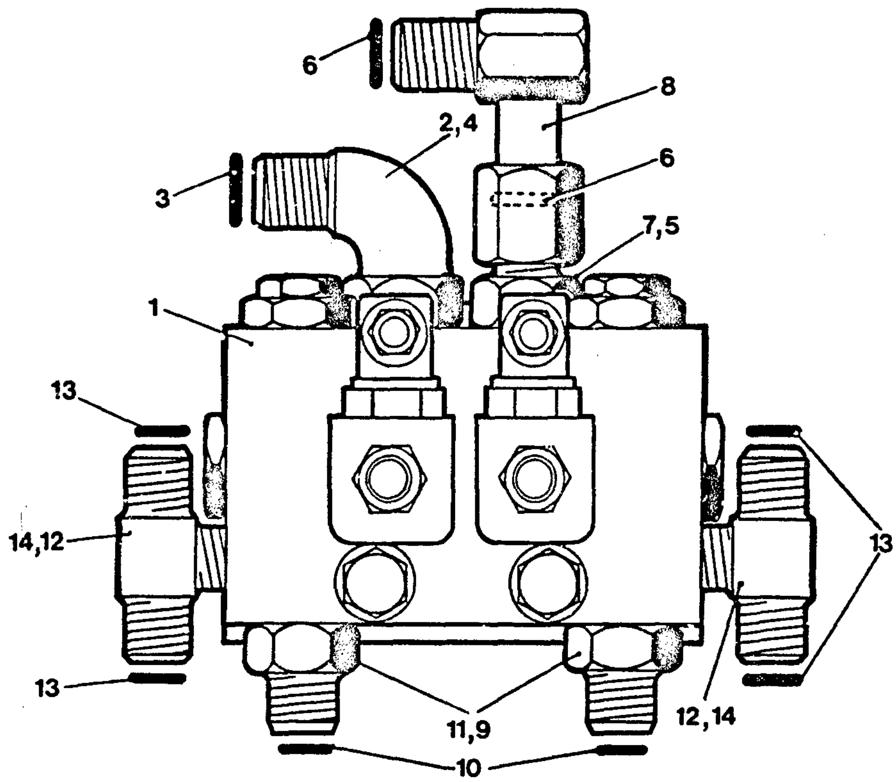
M - METRIC PART

P6R9254

REV 002

6R9254 HYDRAULIC PIPING GROUP - DIFFERENTIAL LOCK

HYDRAULIC SYSTEM

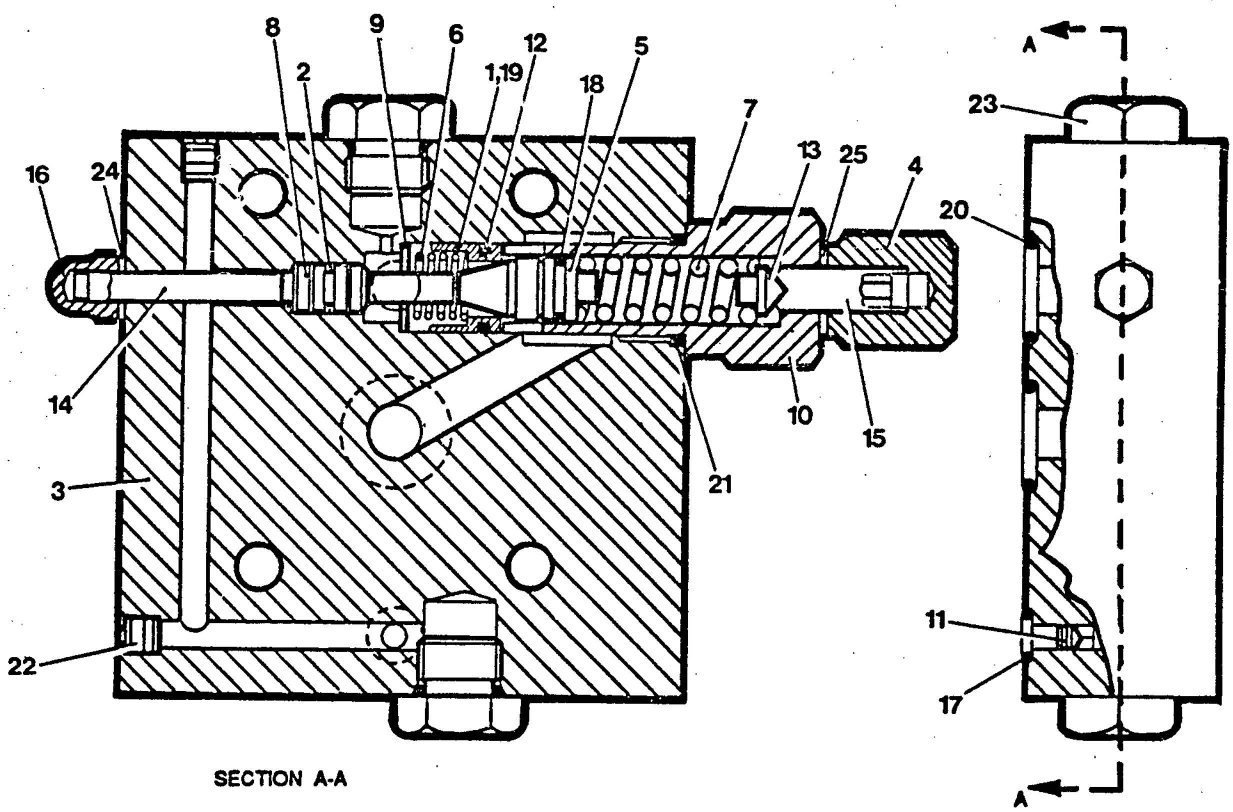


NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	8Q2461	1	COMP CIRCUIT POLYHYDRON
AF	–	838525	1	SEAL KIT
	2	3K0360	1	O RING O.R.B.
	3	6V8398	1	O RING O.R.F.S.
	4	6V8625	1	ELBOW
	5	3K0360	1	O RING O.R.B.
	6	6V8398	2	O RING O.R.F.S.
	7	6V8639	1	ADAPTOR
	8	6V9851	1	SWIVEL ELBOW
	9	3K0360	2	O RING .O.R.B.
	10	6V8398	2	O RING O.R.F.S.
	11	6V8639	2	ADAPTOR
	12	3K0360	2	O RING O.R.B.
	13	6V8397	4	O RING O.R.F.S.
	14	985687	2	TEE

A - NOT PART OF THIS GROUP
F - NOT SHOWN
Y - SEPARATE ILLUSTRATION

P844320 Y
REV 001

844320 COMPENSATING VALVE GROUP
Part of 6R9252 Hydraulic Piping Group - Chassis
8Q2461 - PAGE 178.



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART N'IMBER	QTY	PART NAME
J	1	NSS	1	RING		13	NSS	1	POPPET
J	2	NSS	1	RING		14	NSS	1	STUD
	3	NSS	1	BODY		15	NSS	1	STUD
	4	NSS	1	BLIND NUT		16	NSS	1	BLIND NUT
	5	NSS	1	POPPET	J	17	NSS	1	O RING
J	6	NSS	1	SPRING	J	18	NSS	1	O RING
J	7	NSS	1	SPRING	J	19	NSS	1	O RING
	8	NSS	1	SEAT	J	20	NSS	1	O RING
	9	NSS	1	WASHER	J	21	NSS	1	O RING
	10	NSS	1	TAPPED BLOCK		22	NSS	1	PLUG
	11	NSS	1	PLUG		23	NSS	1	PLUG
	12	NSS	1	SEAT	J	24	NSS	1	COPPER WASHER
					J	25	NSS	1	COPPER WASHER

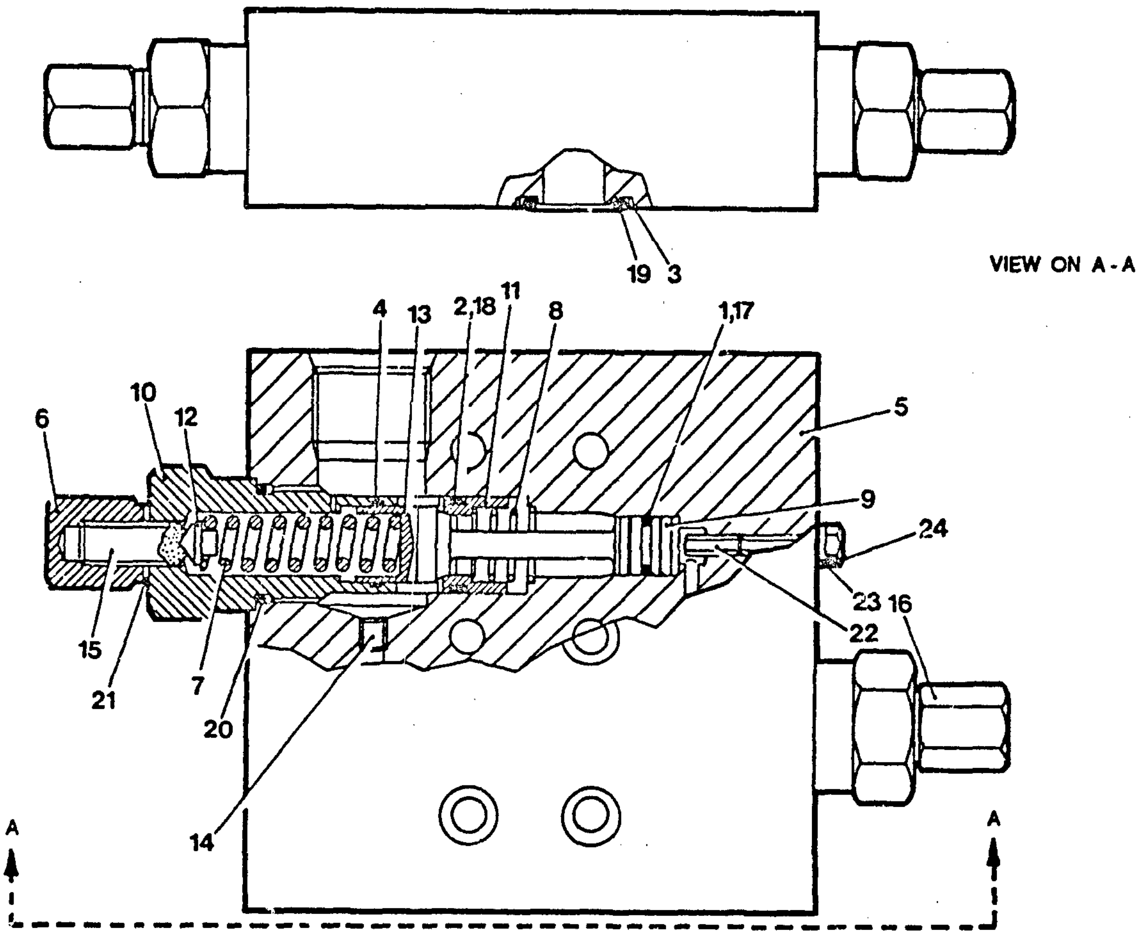
NSS - NOT SERVICED

J - ITEMS INCLUDED IN SEAL KIT 816368

P897301 Y
REV 003

897301 SINGLE OVERCENTER VALVE GROUP
Part of 838021 Boom Raise Ram Group

HYDRAULIC SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
J	1	NSS	1	ANTI-FRICTION RING
J	2	NSS	1	ANTI-FRICTION RING
J	3	NSS	2	BACK-UP RING
J	4	NSS	1	ANTI FRICTION RING
	5	NSS	1	BODY
	6	NSS	1	BLIND NUT
	7	NSS	1	SPRING
	8	NSS	1	SPRING
	9	NSS	1	PISTON
	10	NSS	2	TAPPED PLUG
	11	NSS	1	SEAT
	12	NSS	1	POPPET
	13	NSS	1	SPRING CARRIER
	14	NSS	1	STUD
	15	NSS	1	STUD
	16	NSS	1	PLUG
J	17	NSS	1	O RING
J	18	NSS	1	O RING
J	19	NSS	2	O RING
	20	NSS	2	O RING
	21	NSS	2	COPPER WASHER
	22	NSS	2	STUD
	23	NSS	2	COPPER WASHER
	24	NSS	2	BOLT

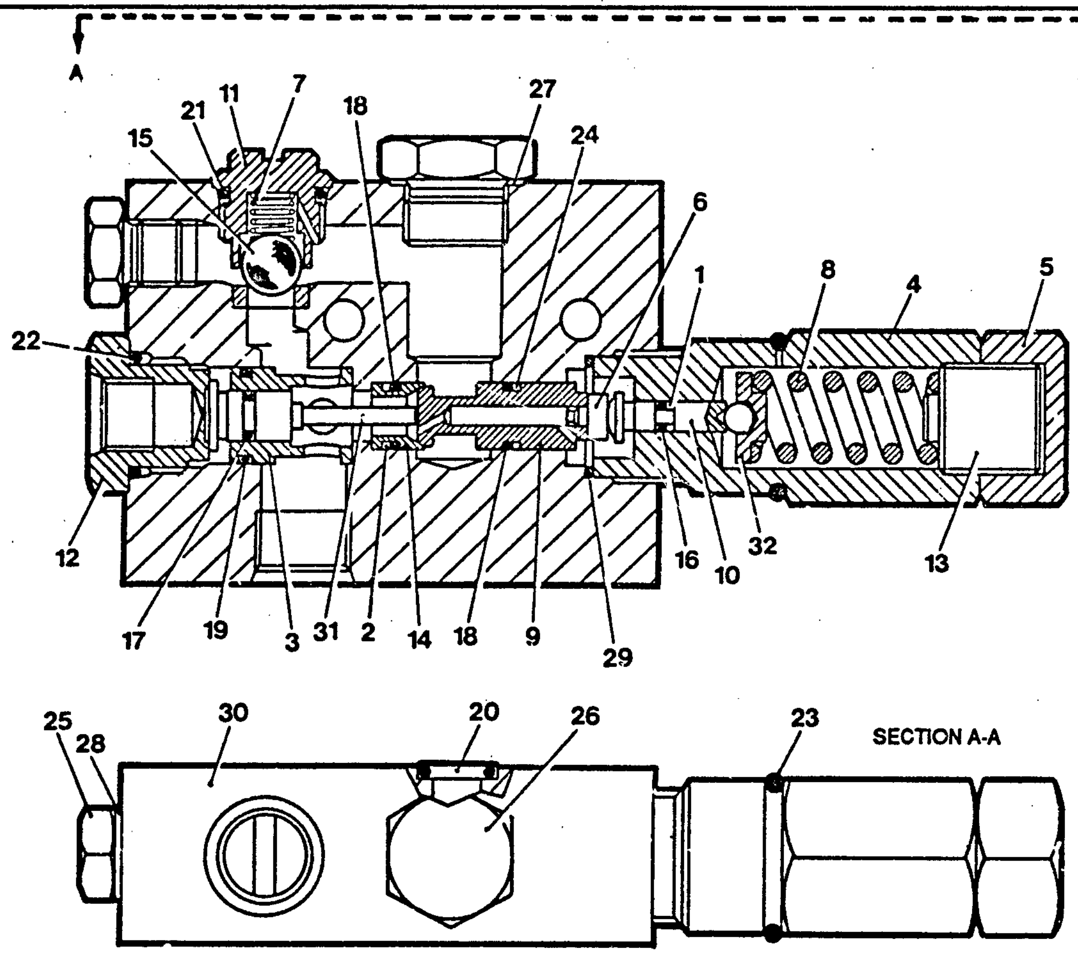
NSS - NOT SERVICED
C - INDICATES CHANGE

J - ITEMS INCLUDED IN SEAL KIT 816367

P897300 Y
REV 003

897300 COUNTERBALANCE VALVE GROUP
Part of 837992 Fork Level Cylinder Group

HYDRAULIC SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
J	1	NSS	1	BACK-UP RING
J	2	NSS	1	BACK-UP RING
	3	NSS	1	PLUNGER
	4	NSS	1	BODY
	5	NSS	1	BLIND NUT
	6	NSS	1	DIAPHRAGM
	7	NSS	1	SPRING
	8	NSS	1	SPRING
	9	NSS	1	PISTON
	10	NSS	1	PISTON
	11	NSS	1	PLUG
	12	NSS	1	PILOT PLUG
	13	NSS	1	CONTROL SCREW

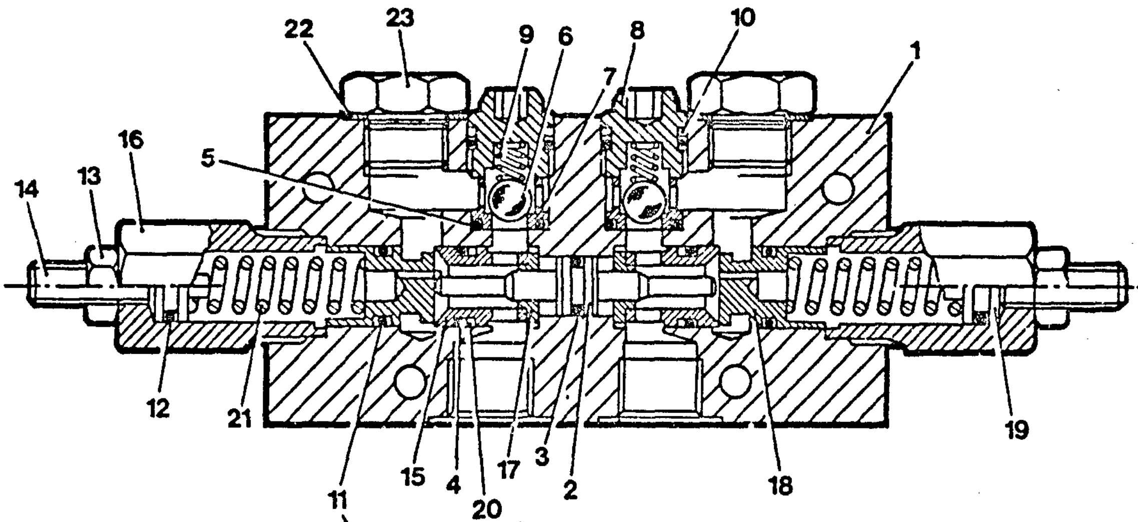
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	14	NSS	1	SEAT
	15	NSS	1	BALL
J	16	NSS	1	O RING
J	17	NSS	1	O RING
J	18	NSS	2	O RING
J	19	NSS	1	O RING
J	20	NSS	1	O RING
J	21	NSS	1	O RING
J	22	NSS	1	O RING
J	23	NSS	1	O RING
J	24	NSS	1	RING
	25	NSS	1	PLUG
	26	NSS	1	PLUG
	27	NSS	1	COPPER WASHER
	28	NSS	1	COPPER WASHER
	29	NSS	1	COPPER WASHER
	30	NSS	1	BODY
	31	NSS	1	PILOT PISTON
	32	NSS	1	WASHER

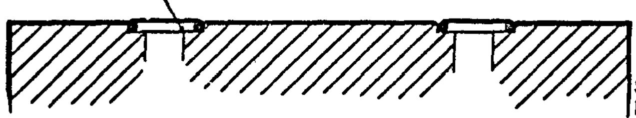
NSS - NOT SERVICED

J - ITEMS INCLUDED IN SEAL KIT 816370

P897299 Y
REV 002

897299 OVERCENTER LOCK VALVE GROUP
Part of 837932 Fork Level Cylinder Group





SECTION SHOWING MOUNTING PORTS

NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	NSS	1	BODY	M	13	NSS	2	LOCK NUT
	2	NSS	2	PILOT PISTON		14	NSS	2	STUD
J	3	NSS	1	O RING		15	NSS	2	SEAT
J	4	NSS	4	O RING		16	NSS	2	TAPPED PLUG
J	5	NSS	2	O RING		17	NSS	2	WASHER
	6	NSS	2	BALL		18	NSS	2	PISTON (SEAT)
	7	NSS	2	SEAT		19	NSS	2	PISTON (SPRING)
	8	NSS	2	TAPPED PLUG	J	20	NSS	2	BACK-UP RING
	9	NSS	2	SPRING		21	NSS	2	SPRING
J	10	NSS	2	BACK-UP RING		22	NSS	1	COPPER WASHER
J	11	NSS	4	O RING		23	NSS	1	PLUG
J	12	NSS	2	O RING					

M - METRIC PART
NSS - NOT SERVICED

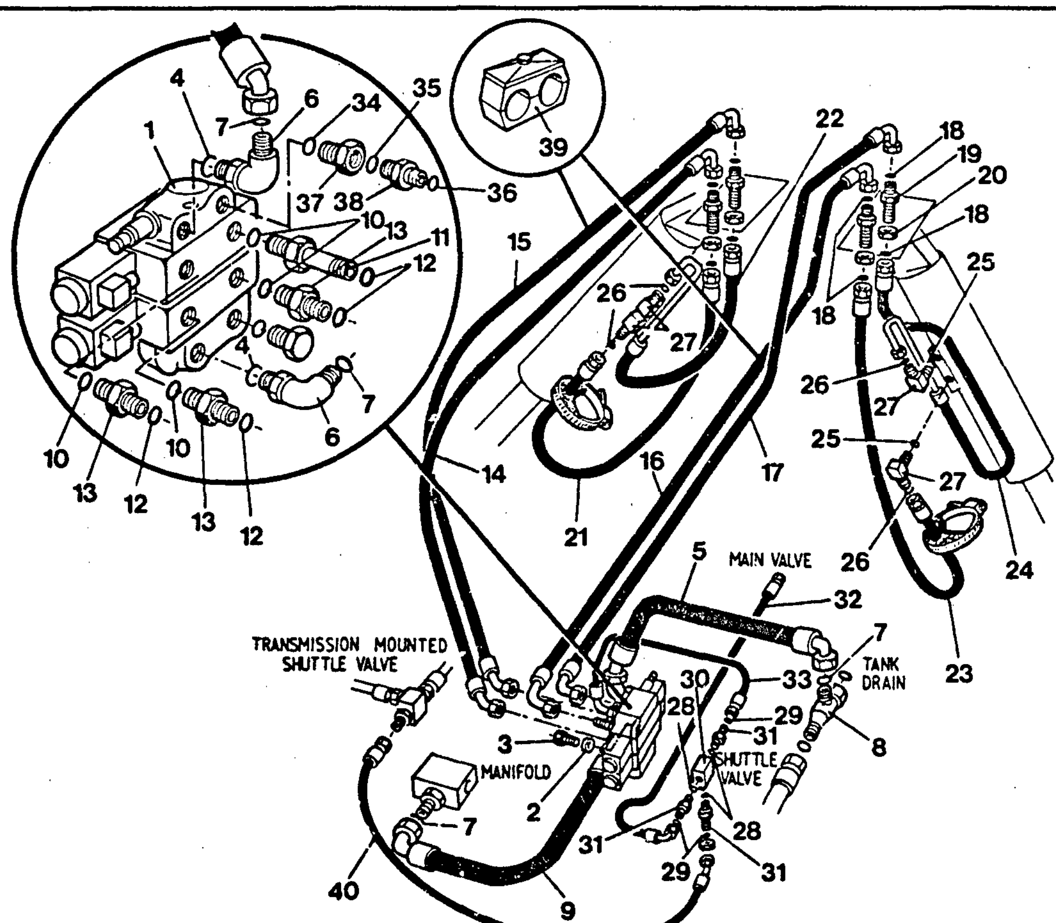
J - ITEMS INCLUDED IN SEAL KIT 816369

P985939
REV 000

985939 DUAL OVERCENTER VALVE GROUP (FRAME LEVELING MACHINES ONLY)

Part of 815517 Frame Level Ram Group

HYDRAULIC SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9017	1	VALVE - HYDRAULIC CONTROL		21	5I0539	1	HOSE AS.
M	2	8T4224	3	WASHER		22	6R9055	1	HOSE AS.
M	3	8T4908	3	BOLT		23	5I0539	1	HOSE AS.
	4	2M9780	2	O RING		24	6R9055	1	HOSE AS.
	5	6R9052	1	HOSE AS.		25	3K0360	4	O RING (ORB)
	6	6V8629	2	ELBOW		26	6V8398	4	O RING (ORFS)
	7	6V9746	4	O RING		27	6V8639	4	ADAPTOR
	8	6V9839	1	TEE		28	3J1907	3	O RING (ORB)
	9	8Q2475	1	HOSE AS.		29	4J5477	3	O RING (ORFS)
	10	3K0360	4	O RING (ORB)		30	6R7605	1	SHUTTLE VALVE
	11	6R9165	1	ADAPTOR (LONG)		31	6V8641	3	ADAPTOR
	12	6V8398	4	O RING (ORFS)		32	6R9056	1	HOSE AS.
	13	6V8639	3	ADAPTOR		33	6R9057	1	HOSE AS.
	14	6R9053	1	HOSE AS		34	2M9780	1	O RING
	15	6R9053	1	HOSE AS.		35	3J1907	1	O RING
	16	6R9054	1	HOSE AS.		36	4J5477	1	O RING (ORFS)
	17	6R9054	1	HOSE AS.		37	5P1404	1	REDUCER
	18	6V8398	8	O RING (ORFS)		38	6V8641	1	ADAPTOR
	19	6V8995	4	BULKHEAD ADAPTOR		39	815759	8	CLAMP
	20	6V9169	4	BULKHEAD NUT		40	8Q2732	1	HOSE AS.

M - METRIC PART

P6R9051 Y
REV 002

6R9051 HYDRAULIC PIPING GROUP - OUTRIGGERS

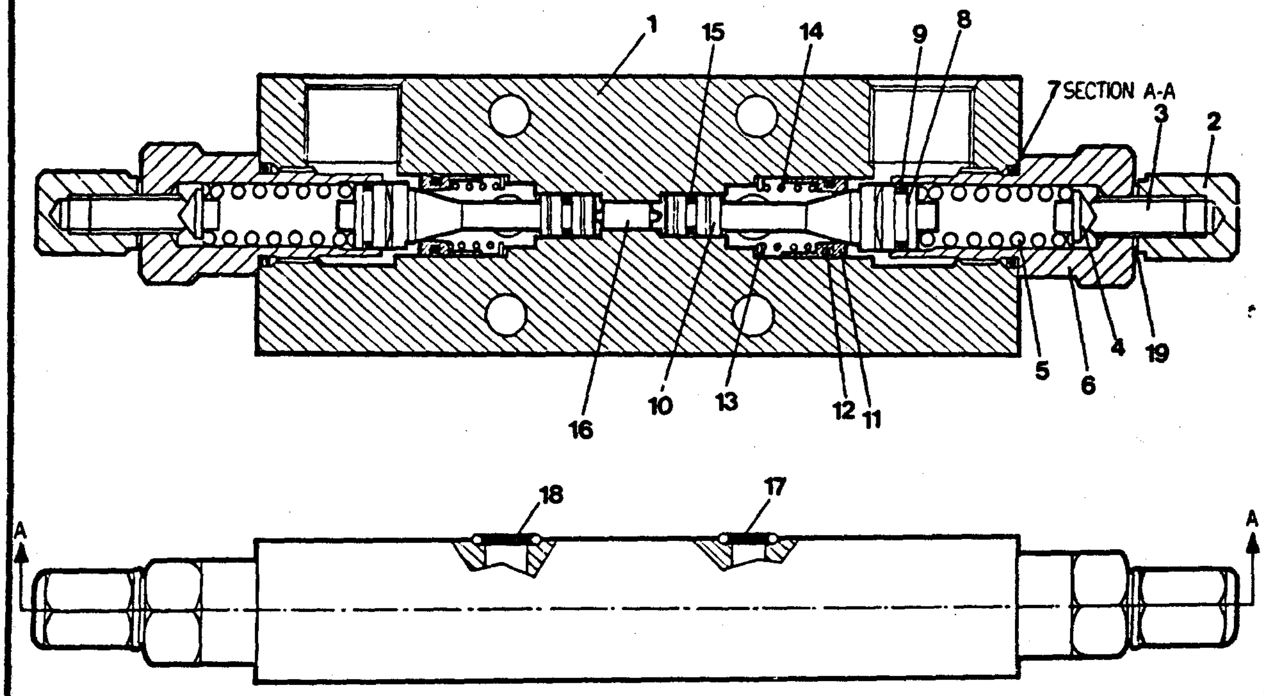
MEMORANDUM

MEMORANDUM

MEMORANDUM

MEMORANDUM

HYDRAULIC SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	NSS	1	BODY
	2	NSS	2	BLIND NUT
	3	NSS	2	STUD
	4	NSS	2	POPPET
	5	NSS	2	SPRING
	6	NSS	2	TAPPED PLUG
J	7	NSS	2	O. RING
	8	NSS	2	POPPET
J	9	NSS	2	O. RING
	10	NSS	2	SEAT
	11	NSS	2	SEAT
	12	NSS	2	O. RING
	13	NSS	2	COPPER WASHER
	14	NSS	2	SPRING
J	15	NSS	2	O. RING
J	16	NSS	1	POPPET
J	17	NSS	1	O. RING
J	18	NSS	1	O. RING
	19	NSS	2	WASHER

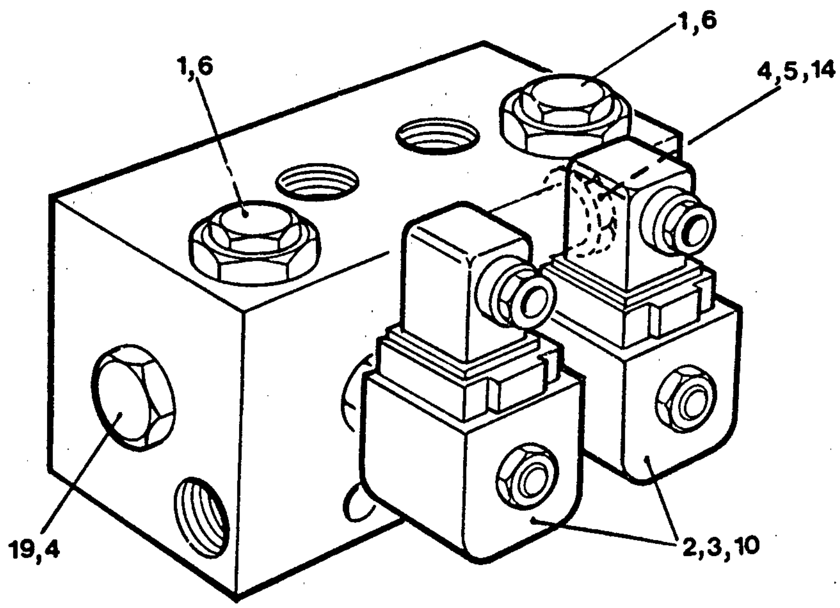
NSS - NOT SERVICED

J - ITEMS INCLUDED IN SEAL KIT 8Q2076

P844102 Y
REV 001

844102 DUAL OVERCENTRE VALVE GROUP
Part of 844103 Outrigger Ram Group

HYDRAULIC SYSTEM



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	8Q2679	2	RELIEF VALVE
	2	8Q2680	2	SOLENOID VALVE ;- INCLUDING,
	3	8Q2681	2	COIL
	4	8Q2682	2	CHECK VALVE
	5	8Q2683	1	PILOT PISTON

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	6	8Q2663	1	SEAL KIT (RELIEF VALVE)
	F	8Q2664	1	O. RING
	F	8Q2665	1	O. RING
	F	8Q2666	1	BACK UP RING
	10	8Q2667	1	SEAL KIT (SOLENOID VALVE)
	F	8Q2668	1	O. RING
	F	8Q2669	1	O. RING
	F	8Q2670	1	BACK UP RING
	14	8Q2671	1	SEAL KIT (P.O. CHECK VALVE)
	F	8Q2664	1	O. RING
	F	8Q2573	2	O. RING
	F	8Q2674	3	BACK UP RING
	F	8Q2675	1	RING
	19	8Q2676	1	SEAL KIT (CHECK VALVE)
	F	8Q2664	1	O. RING
	F	8Q2673	2	O. RING
	F	8Q2674	3	BACK UP RING

F - NOT SHOWN

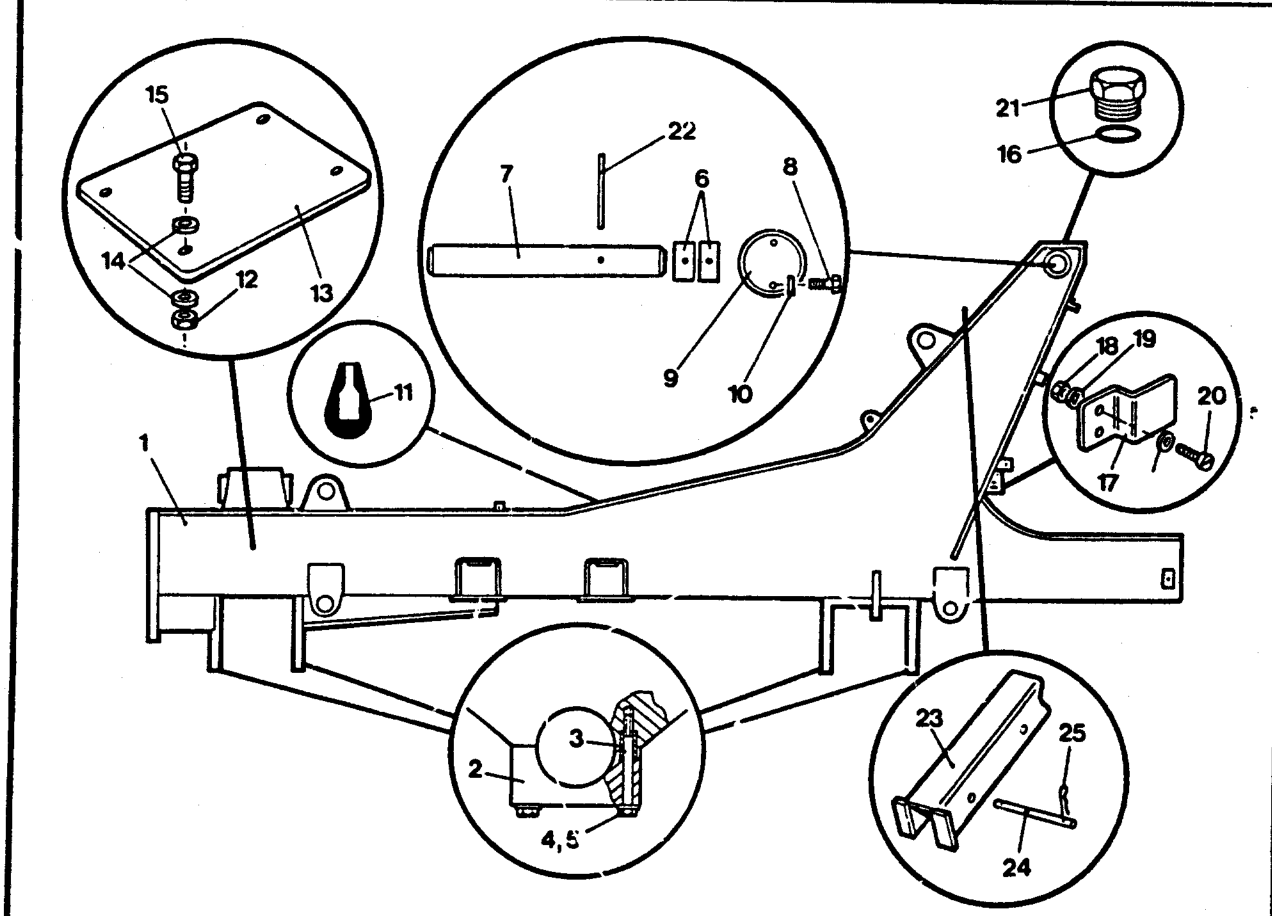
NOTE ; TWO SEAL KITS ITEMS 6 AND 10 REQUIRED TO SERVICE COMPLETE VALVE.

P8Q2461 Y

REV 001

8Q2461 COMPENSATING MANIFOLD WITH BY-PASS
Part of 844320 Compensating Valve Group

FRAME AND PANELS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	837945	1	CHASSIS FRAME AS.
NSS	2	———	4	KEEP
	3	8T1584	8	BUSHING
M	4	8T0650	8	BOLT
M	5	5P8247	8	WASHER
	6	897354	4	BUSH
	7	6R7899	1	PIVOT PIN
M	8	5C9553	4	BOLT
	9	815933	2	END COVER
M	10	8T4205	4	WASHER
D	11	816274	1.0	EDGING
M	12	6V7744	4	NUT - SELF LOCKING
	13	838781	1	TOP PLATE
M	14	8T4121	8	WASHER
M	15	8T4196	4	BOLT
	16	3K0360	2	O. RING O.R.B.
	17	6R7946	2	PLATE CATCH
M	18	6V7743	4	NYLOC NUT
M	19	8T4205	8	WASHER
M	20	8T6412	4	SCREW
	21	9S4185	2	PLUG
	22	6R7924	1	ROLL PIN
	23	6R7486	2	CLAMP AS.
	24	6R9007	4	PIN
	25	6V9197	8	R. CLIP

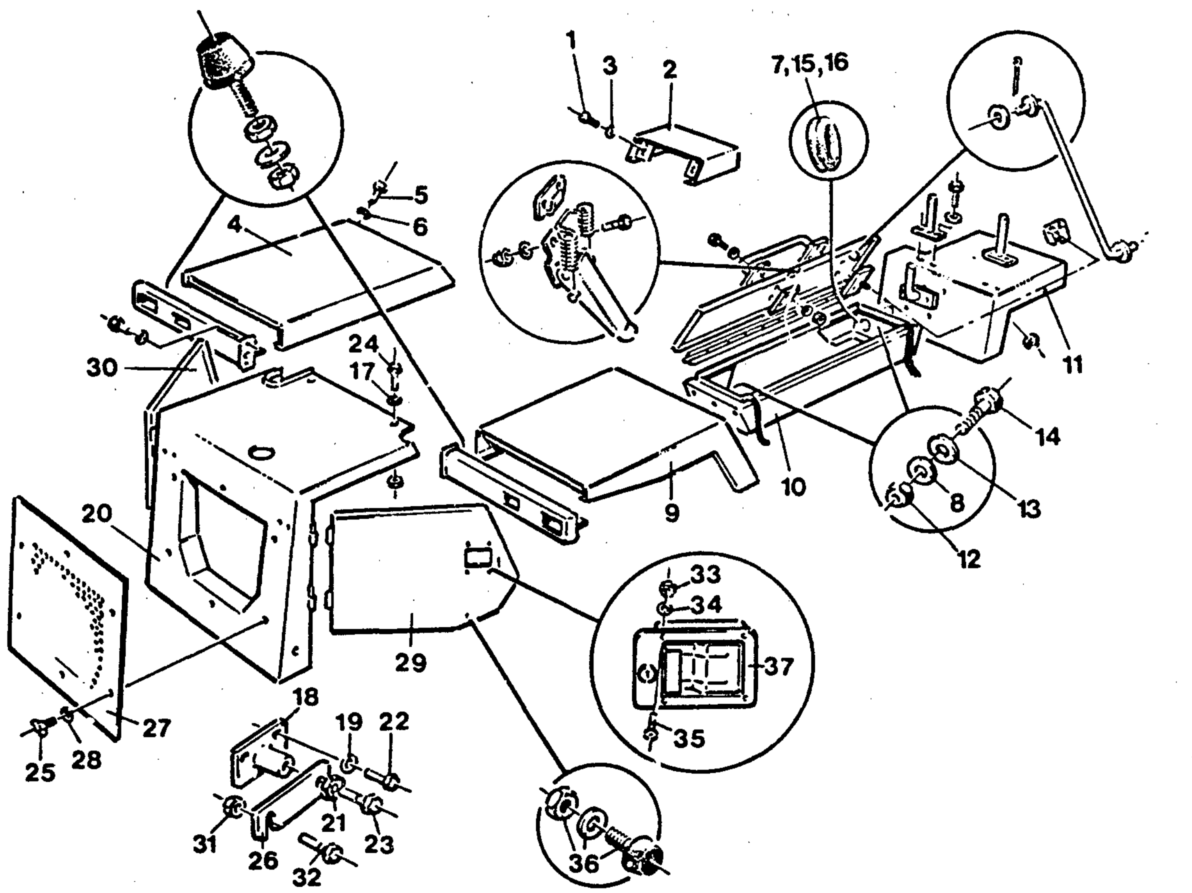
M - METRIC PART
D - ORDER BY THE METER

NSS - NOT SERVICED

P837967 Y
REV 004

837967 CHASSIS FRAME GROUP

FRAME AND PANELS



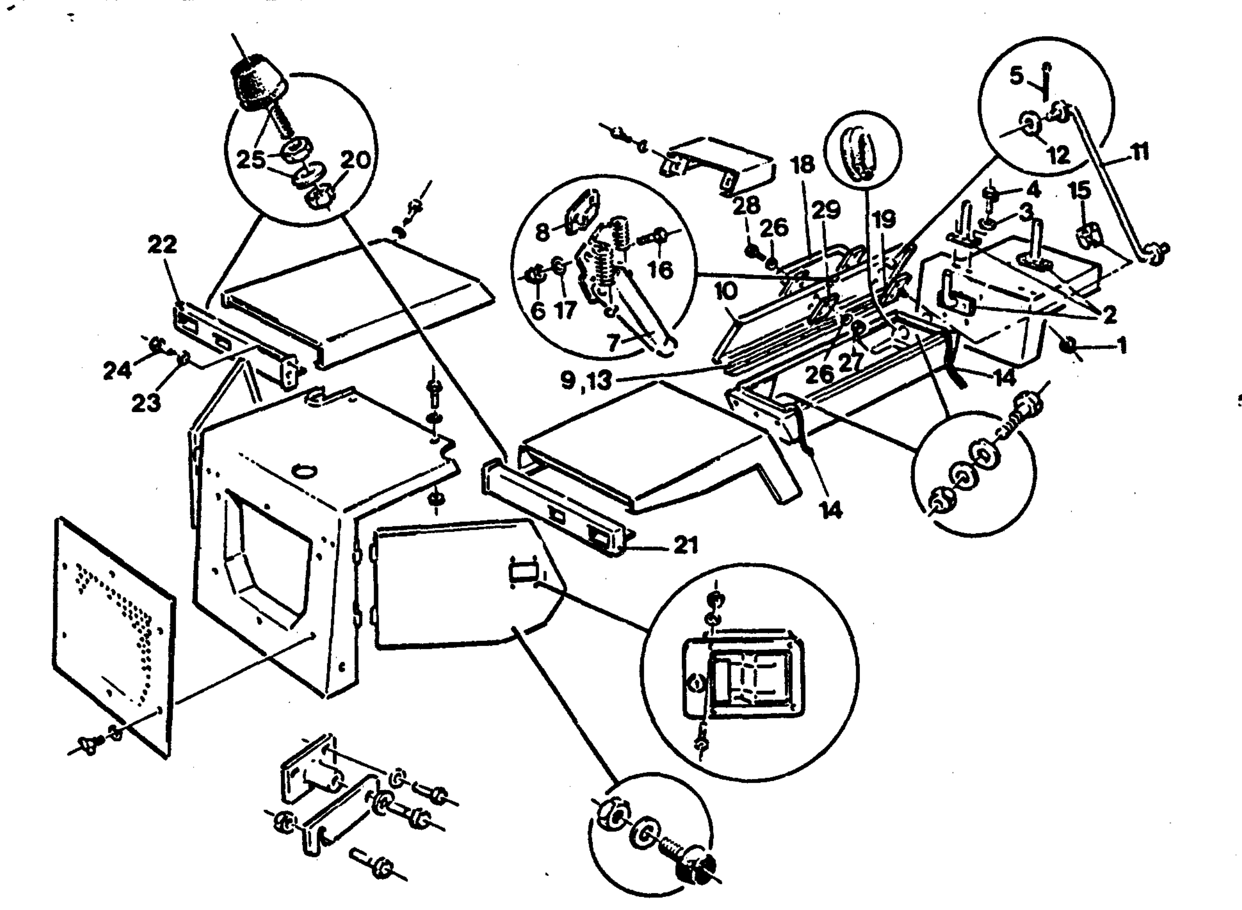
NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	7X2548	4	BOLT
	2	844131	1	FRONT DECKING AS.
M	3	8T4223	4	WASHER
	4	6R7592	1	REAR DECKING AS.
M	5	7X2548	4	BOLT
M	6	8T4223	4	WASHER
	7	3H2900	2	GROMMET
M	8	5P4116	12	WASHER
	9	6R9031	1	REAR WING AS.
	10	6R9032	1	CENTRE WING AS.
	11	6R9033	1	FRONT WING AS.
M	12	6V9189	24	NYLOC NUT
M	13	897961	36	WASHER
M	14	8T4189	24	BOLT
	15	2U4578	2	GROMMET
	16	9D7303	1	GROMMET
M	17	5P1076	4	WASHER
	18	6R7753	2	CATCH AS. - COWL
M	19	6V5839	4	WASHER
	20	838628	1	ENGINE COWL AS.
M	21	8T4133	2	NUT
M	22	8T4136	4	BOLT
M	23	8T4186	2	BOLT
M	24	8T4192	4	BOLT
	25	6R7613	5	WING BOLT
	26	6R7755	2	LATCH
	27	6R9163	1	RADIATOR GRI ˙.E
M	28	7X7729	6	WASHER
	29	838635	1	COWL DOOR AS.
	30	838658	1	COWL DOOR AS.
M	31	8T4133	2	NUT
M	32	8T4136	2	BOLT
M	33	6V7743	8	NYLOC NUT
M	34	8T4205	8	WASHER
M	35	8T6411	8	SCREW
	36	985613	2	G.M.T.BUFFER
	37	9X2299	2	LATCH

M - METRIC PART

P6R7741 Y
REV 008

6R7741 ENGINE COWL AND PLATFORM GROUP (1 of 2)

FRAME AND PANELS



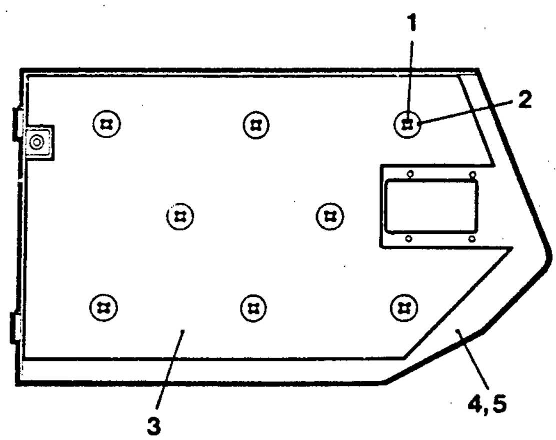
NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V7744	6	NUT - SELF LOCKING
NSSY	2	8Q2077	1	MIRROR GROUP
M	3	8T4121	6	WASHER
M	4	8T4136	6	BOLT
	5	3B4609	1	COTTER PIN
M	6	3T0851	4	NUT- SELF LOCKING
	7	3U2004	1	FASTENER
	8	5U5009	1	CATCH PLATE
	9	6R7680	1	HINGE CONTINUOUS
	10	6R9102	1	PLATFORM COVER AS.
	11	6R9111	1	STAY AS.- TANK LID
M	12	6V7699	1	WASHER
M	13	8Q2078	20	RIVET
	14	815720	2	SEAL (0.86M LONG)
	15	816087	1	PLASTIC CLIP
M	16	8T0288	4	BOLT
M	17	8T0328	4	WASHER
	18	8Q2069	1	GRAB HANDLE
	19	8Q2074	1	PLATE AS.
M	20	5C2890	4	NUT
	21	6R7589	1	BRACKET WELD AS. R.H.
	22	6R7590	1	BRACKET WELD AS. L.H.
M	23	8T4121	4	WASHER
M	24	8T4137	4	BOLT
	25	985613	4	G.M.T.BUFFER
M	26	6V5839	8	WASHER
M	27	6V7744	4	NYLOG NUT
M	28	8T4137	4	BOLT
M	29	985250	1	PLATE

M - METRIC PART
NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION

P6R7741 Y
REV 008

6R7741 ENGINE COWL AND PLATFORM GROUP (2 of 2)
8Q2077 - PAGE 237

FRAME AND PANELS



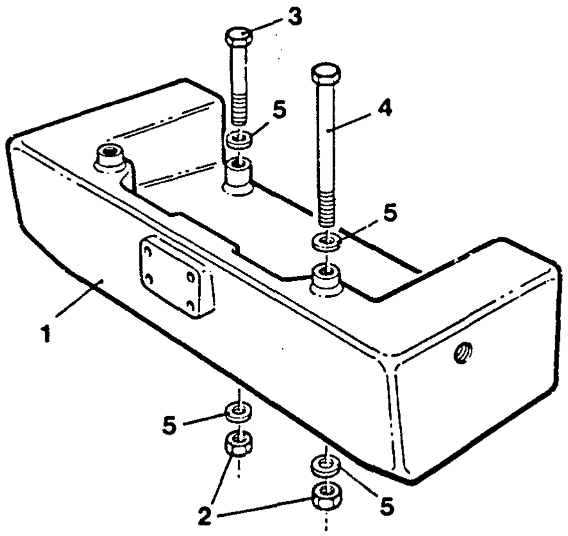
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	F	539694	8	METAL TACK FASTENER
NSS	F	8C8940	1	PLATE - EXTERIOR SOUND 108
NSS	F	8C9053	1	PLATE - OPERATOR SOUND 85
	1	2U2752	16	CLIP - RETAINING
	2	2U2770	16	WASHER - STARLOCK
	3	6R7498	2	ENGINE COWL DOOR SOUND INST.
	4	6R8917	1	ENG COWL DOOR AS L.H.
	5	6R8918	1	ENG COWL DOOR AS R.H.

NSS - NOT SERVICED
F - NOT SHOWN

P6R7876 Y
REV000

6R7876 SOUND SUPPRESSION GROUP (COSA)

FRAME AND PANELS



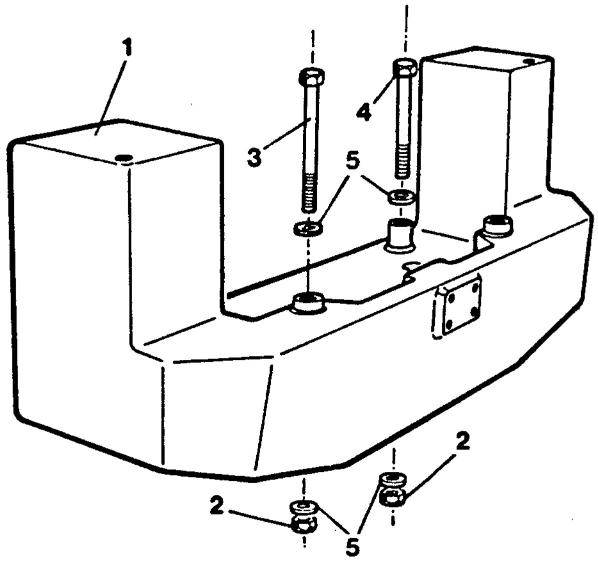
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9006	1	BALLAST WEIGHT
M	2	6V7688	4	NYLOC NUT
M	3	6V9167	2	BOLT
M	4	897988	2	BOLT
M	5	8T3282	8	WASHER

M - METRIC PART

P6R9022 Y
REV000

6R9022 BALLAST WEIGHT GROUP (RT80)

FRAME AND PANELS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815521	1	BALLAST WEIGHT
M	2	6V7688	4	NYLOC NUT
M	3	8C3750	2	BOLT
M	4	8T0658	2	BOLT
M	5	8T3282	8	WASHER

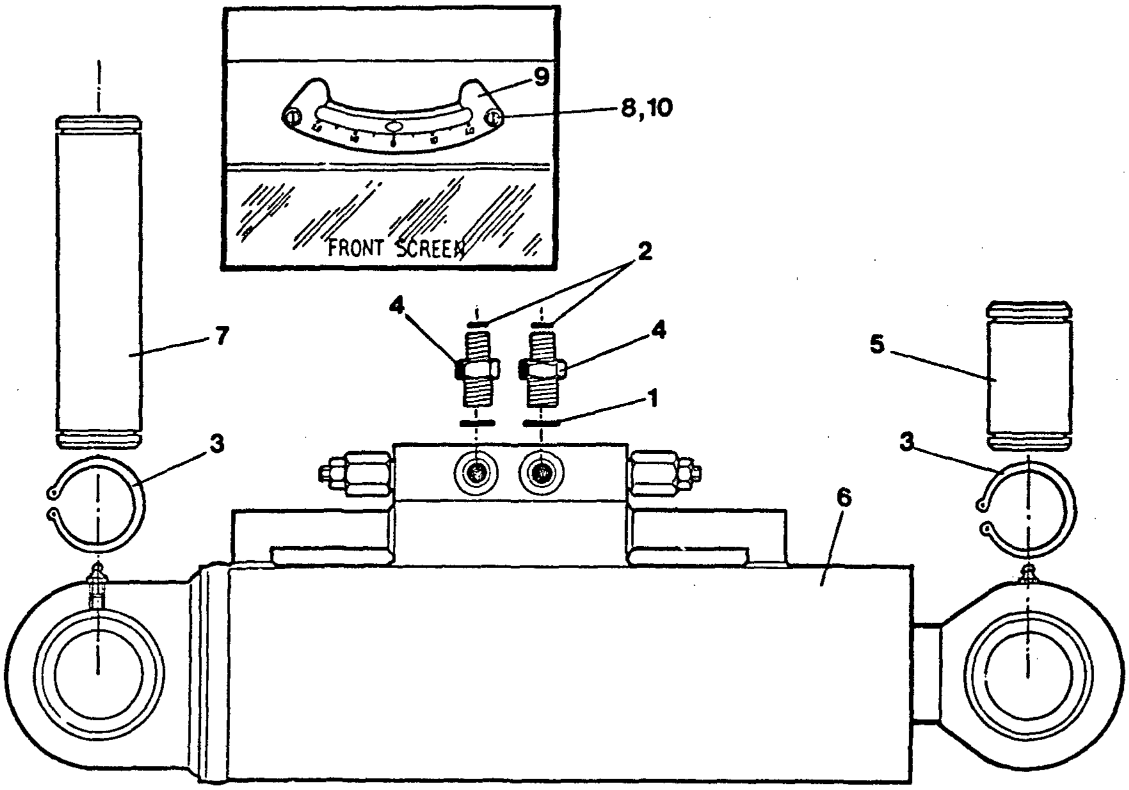
M - METRIC PART

P6R7688 Y

REV 001

6R7688 BALLAST WEIGHT GROUP (RT100)

FRAME AND PANELS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3J1907	2	O RING	Y	6	815517	1	FRAME LEVEL CYLINDER GROUP
	2	4J5477	2	O RING (ORFS)		7	897500	1	PIN
	3	6V5204	4	SNAP RING	M	8	6V9499	2	WASHER
	4	6V8641	2	ADAPTOR		9	838535	1	LEVEL INDICATOR
	5	815498	1	PIN	M	10	8T0257	2	SCREW

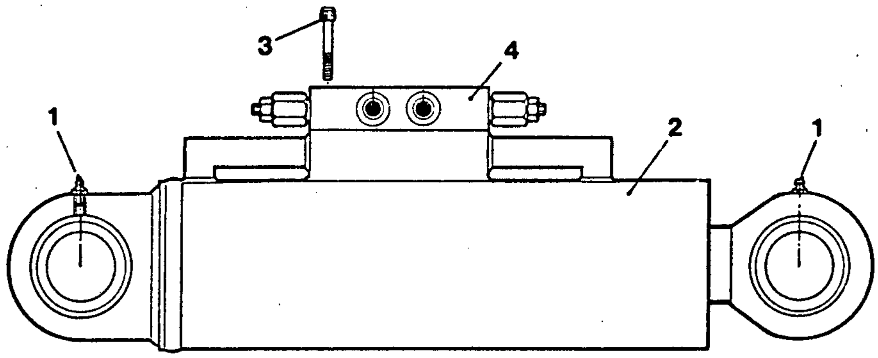
M - METRIC PART
Y - SEPARATE ILLUSTRATION

P815516 Y
REV 003

815516 FRAME LEVEL GROUP

815517 - PAGE 186

FRAME AND PANELS



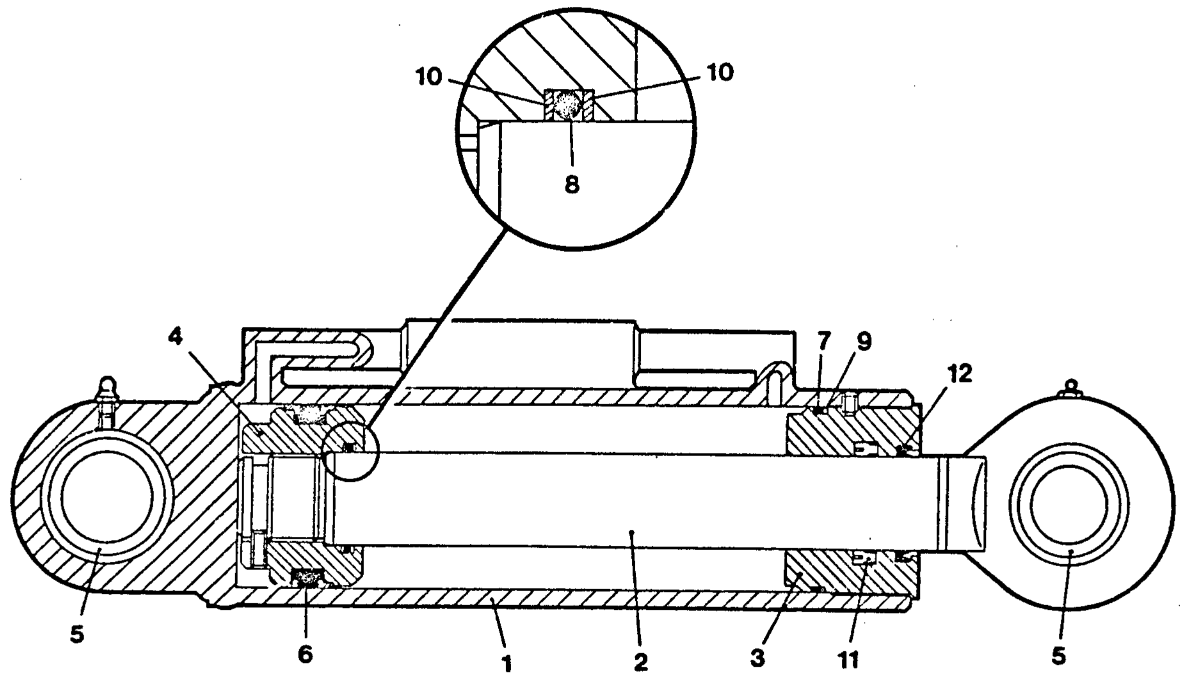
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
						1	3B8488	2	GREASE NIPPLE
					Y	2	897937	1	FRAME LEVEL RAM
					M	3	8T8442	4	SCREW
					Y	4	985939	1	DUAL OVERCENTRE VALVE

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P815517 Y
REV 000

815517 FRAME LEVEL RAM GROUP
897937 - PAGE 187. 985939 - PAGE 173.

FRAME AND PANELS



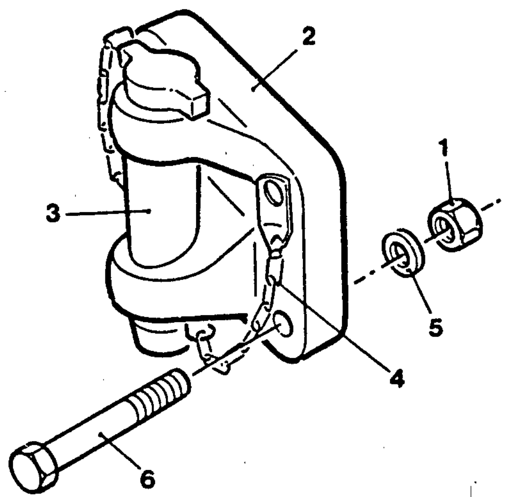
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	5I0601	1	CYLINDER AS
	2	5I0602	1	PISTON ROD AS
	3	5I0603	1	GLAND
	4	5I0604	1	PISTON
	5	975448	1	SPHERICAL BEARING

NOTE	REF NO	PART NUMBER	QTY	PART NAME
		6R7781	1	SEAL KIT
	6	5I0583	1	SEAL
	7	5I0584	1	O RING
	8	5I0585	1	O RING
	9	5I0586	1	RING
	10	5I0587	2	RING
	11	5I0605	1	SEAL
	12	5I0606	1	WIPER

P[illegible]7937 Y
REV001

897937 FRAME LEVEL RAM GP
Part of 815517 Frame Level Ram GP

FRAME AND PANELS (AN ATTACHMENT)



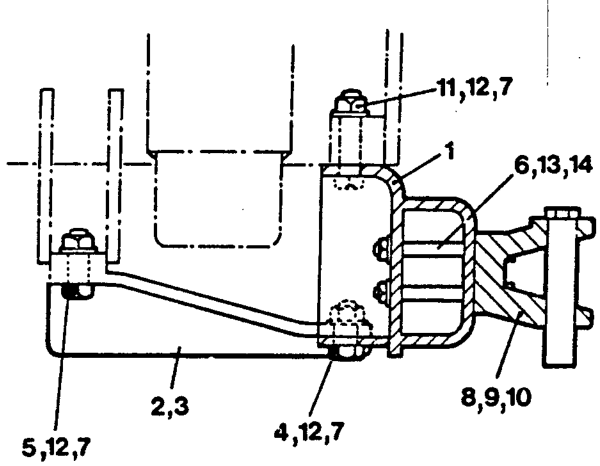
NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V7687	4	NYLOC NUT
	2	898010	1	TOWING JAW GROUP.
	3	815479	1	PIN, TAG AND CHAIN
	4	815480	1	CHAIN, TAG AND CLIP
M	5	8T4223	4	WASHER
M	6	8T5001	4	BOLT

M - METRIC PART

P838828 Y
REV 000

838828 TOWING HOOK GROUP

FRAME AND PANELS



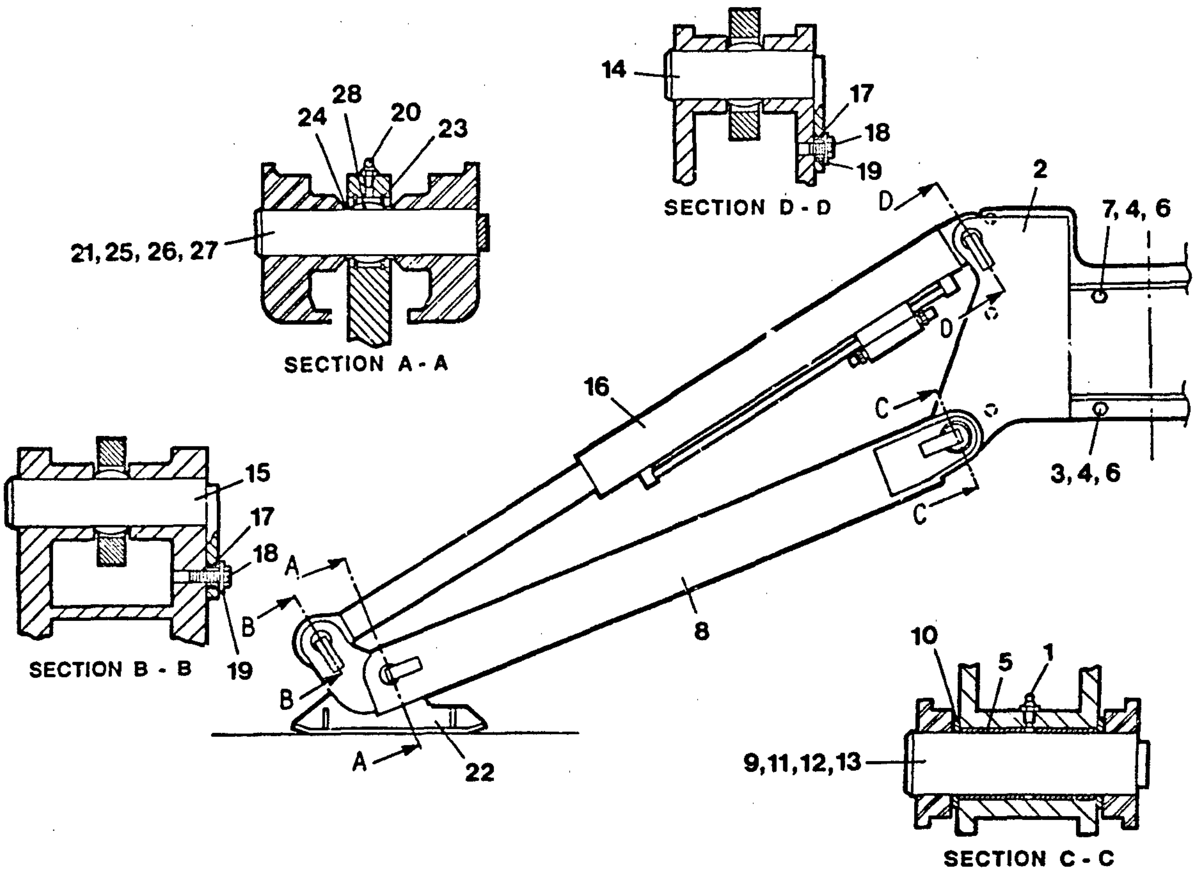
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9331	1	TOW BAR WELD AS.
	2	6R9334	1	STIFFENER L.H. AS
	3	6R9335	1	STIFFENER R.H. AS
M	4	6V3531	2	BOLT
M	5	6V3532	2	BOLT
M	6	6V7687	4	NYLOC NUT
M	7	6V7688	6	NYLOC NUT
	8	898010	1	TOWING JAW AS. INCLUDING;-
	9	815479	1	PIN, TAG AND CHAIN
	10	815480	1	CHAIN, TAG AND CLIP
M	11	8T0360	2	BOLT
M	12	8T3282	6	WASHER
M	13	8T4223	4	WASHER
	14	8T5001	4	BOLT

M - METRIC PART

P6R9336 Y
REV000

6R9336 TOWING HOOK GROUP - RT80 (COSA)

FRAME AND PANELS (AN ATTACHMENT)



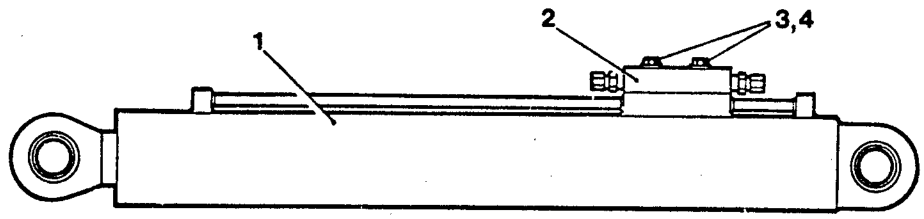
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3B8488	2	GREASE NIPPLE		15	8Q2086	2	PIN AS
	2	6R8943	1	BRACKET AS	YNSS	16	844103	2	OUTRIGGER RAM GROUP
M	3	6V3669	8	BOLT		17	897338	4	SLEEVE
	4	6V7742	10	NUT	M	18	8T4195	4	BOLT
M	5	897352	4	BUSH	M	19	8T4222	4	WASHER
M	6	8T3282	10	WASHER		20	3B8488	2	GREASE NIPPLE
	7	986000	2	BOLT		21	6R8983	2	PIN AS
	8	6R8955	2	OUTRIGGER BEAM AS		22	844005	2	OUTRIGGER FOOT AS
	9	6R8978	2	PIN AS		23	844036	4	CIRCLIP INTERNAL
	10	6R8985	4	WASHER		24	844039	4	SPACER
	11	897338	2	SLEEVE		25	897338	2	SLEEVE
M	12	8T4195	2	BOLT	M	26	8T4195	2	BOLT
M	13	8T4222	2	WASHER	M	27	8T4222	2	WASHER
	14	6R3981	2	PIN AS		28	975448	2	SPHERICAL BEARING

M - METRIC PART NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION

P6R8977 Y
REV 002

6R8977 OUTRIGGER BEAM GROUP
844103 - PAGE 190

FRAME AND PANELS (AN ATTACHMENT)



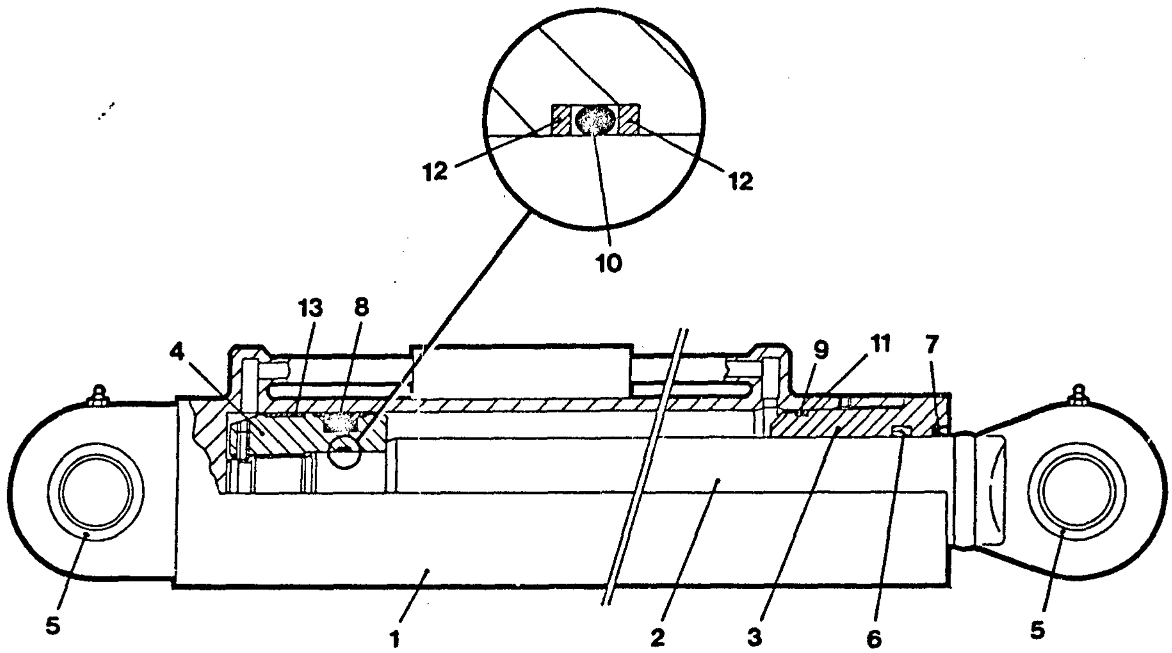
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
					Y	1	838934	1	OUTRIGGER RAM
					Y	2	844102	1	DUAL OVERCENTRE VALVE
					M	3	8T4224	4	WASHER
					M	4	8T6912	4	BOLT

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P844103 Y
REV 000

844103 OUTRIGGER RAM GROUP
844102 - PAGE 177. 838934 - PAGE 191

FRAME AND PANELS (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	5I0579	1	CYLINDER AS
	2	5I0580	1	PISTON ROD AS
	3	5I0581	1	GLAND
	4	5I0582	1	PISTON
	5	975448	2	SPHERICAL BEARING

NOTE	REF NO	PART NUMBER	QTY	PART NAME
		6R7783	1	SEAL KIT
	6	5I0557	1	SEAL
	7	5I0558	1	WIPER
	8	5I0583	1	SEAL
	9	5I0584	1	O RING
	10	5I0585	1	O RING
	11	5I0586	1	RING
	12	5I0587	2	RING
	13	5I0588	1	RING

P638934 Y

REV001

838934 OUTRIGGER RAM GP

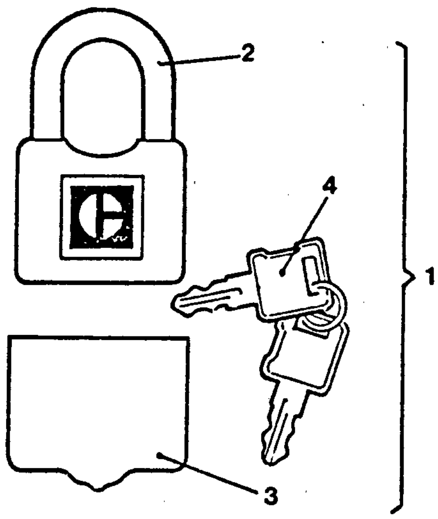
Part of 844103 Outrigger Ram GP

MEMORANDUM

MEMORANDUM

MEMORANDUM

FRAME AND PANELS (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	5P8502	4	PADLOCK GP, COMPRISING:
	2	NSS	1	PADLOCK
	3	6V5874	1	COVER
	4	5P8500	2	KEY

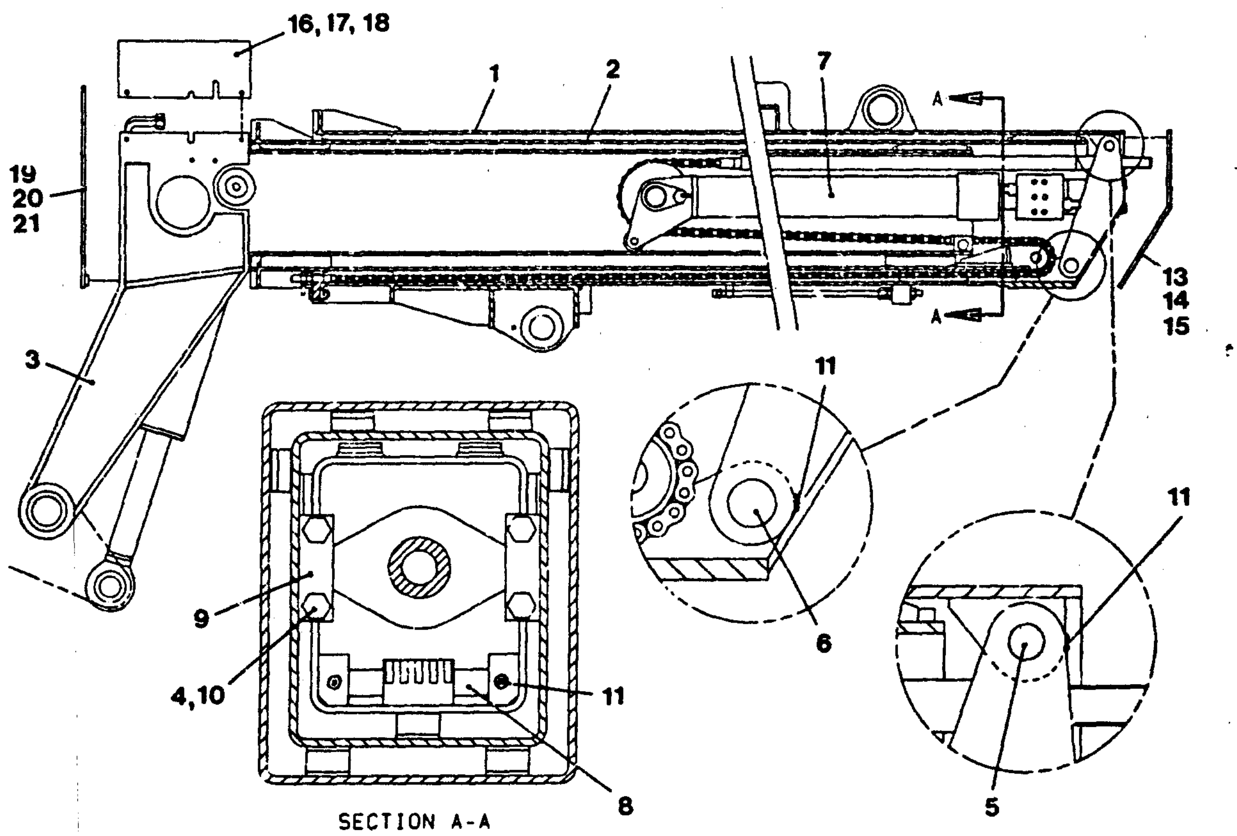
NSS - NOT SERVICED

P6R7729

REV001

6R7729 VANDALISM GROUP

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
NSSY	1	985889	1	No.1 BOOM SECTION GP
NSSY	2	985979	1	No.2 BOOM SECTION GP
NSSY	3	986070	1	BOOM HEAD SECTION GP
M	4	6V3532	4	BOLT
	5	837989	1	TOP ANCHOR SHAFT
	6	837990	1	BOTTOM ANCHOR SHAFT
NSSY	7	837991	1	TELESCOPING GP
	8	897359	1	CHAIN ANCHOR SHAFT
	9	897367	2	KEEP PLATE
M	10	8T3282	4	WASHER
M	11	8TO351	6	SET SCREW
	13	837993	1	REAR COVER
M	14	8C8585	4	SCREW
M	15	8T4121	4	WASHER
	16	6R8922	1	BOOM HEAD COVER
M	17	8T4121	4	WASHER
M	18	8T4137	4	BOLT
	19	837995	1	FRONT COVER
M	20	8T-137	6	SCREW
M	21	8T4121	6	WASHER
NSSY	F	844146	1	ELECTRICAL GROUP - BOOM
NSSY	F	838010	1	BOOM HYDRAULIC GROUP
NSSY	F	838524	1	QUICK HITCH GROUP
NSSY	F	838024	1	COMPENSATING GROUP

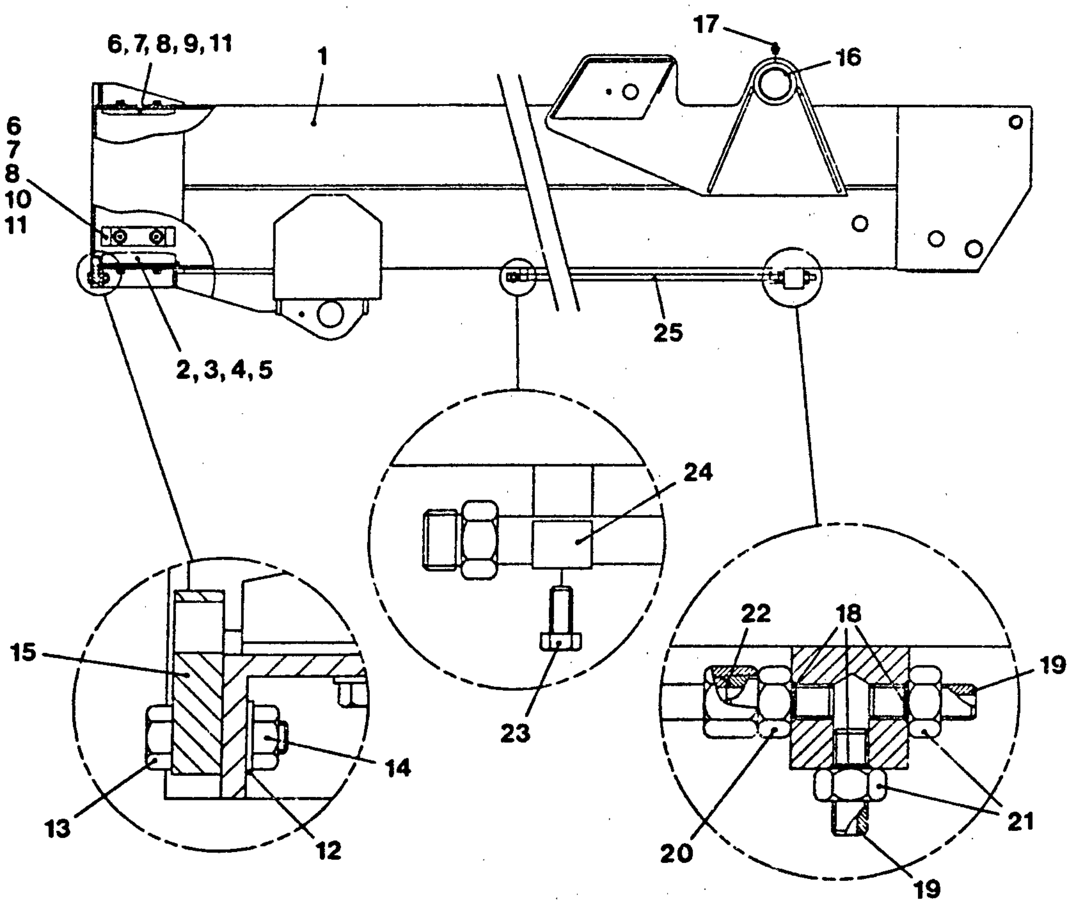
Y - SEPARATE ILLUSTRATION
F - NOT SHOWN
M - METRIC PART
NSS - NOT SERVICED

P985888 Y
REV005

985888 3-SECTION BOOM GRP (WITH COMPENSATING CYLINDERS)

985889 - PAGE 196, 985979 - PAGE 197, 986070 - PAGE 198, 837991 - PAGE 199.
844146 - PAGE 265, 838010 - PAGE 209, 838524 - PAGE 223, 838024 - PAGE 214.

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	985890	1	NO.1 BOOM SECTION AS	M	14	6V8149	2	NUT
M	2	897344	2	SHIM 5MM		15	897321	1	CHAIN BRACKET
M	3	8T4121	4	WASHER	M	16	897345	2	BUSH
M	4	8T4195	4	BOLT		17	3B8488	2	GREASE NIPPLE
Y	5	985845	2	WEAR PAD GP		18	3K0360	8	O RING
MB	6	897342	-	SHIM 0.75MM		19	6V8398	6	O RING
MB	7	897343	-	SHIM 1.5MM		20	6V8632	2	ADAPTOR
M	8	8T4121	8	WASHER		21	6V8639	6	ADAPTOR
M	9	8T4136	4	BOLT		22	7J9108	2	O RING
M	10	8T4196	4	BOLT	M	23	5C9553	2	BOLT
Y	11	985843	4	WEAR PAD GP		24	815943	2	PIPE CLIP
M	12	5P8245	2	WASHER		25	985977	2	STEEL PIPE AS
M	13	6V7673	2	BOLT	NSSY	F	815728	1	ROLLING HOSE GP

B - USE AS REQUIRED
M - METRIC PART

NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION
F - NOT SHOWN

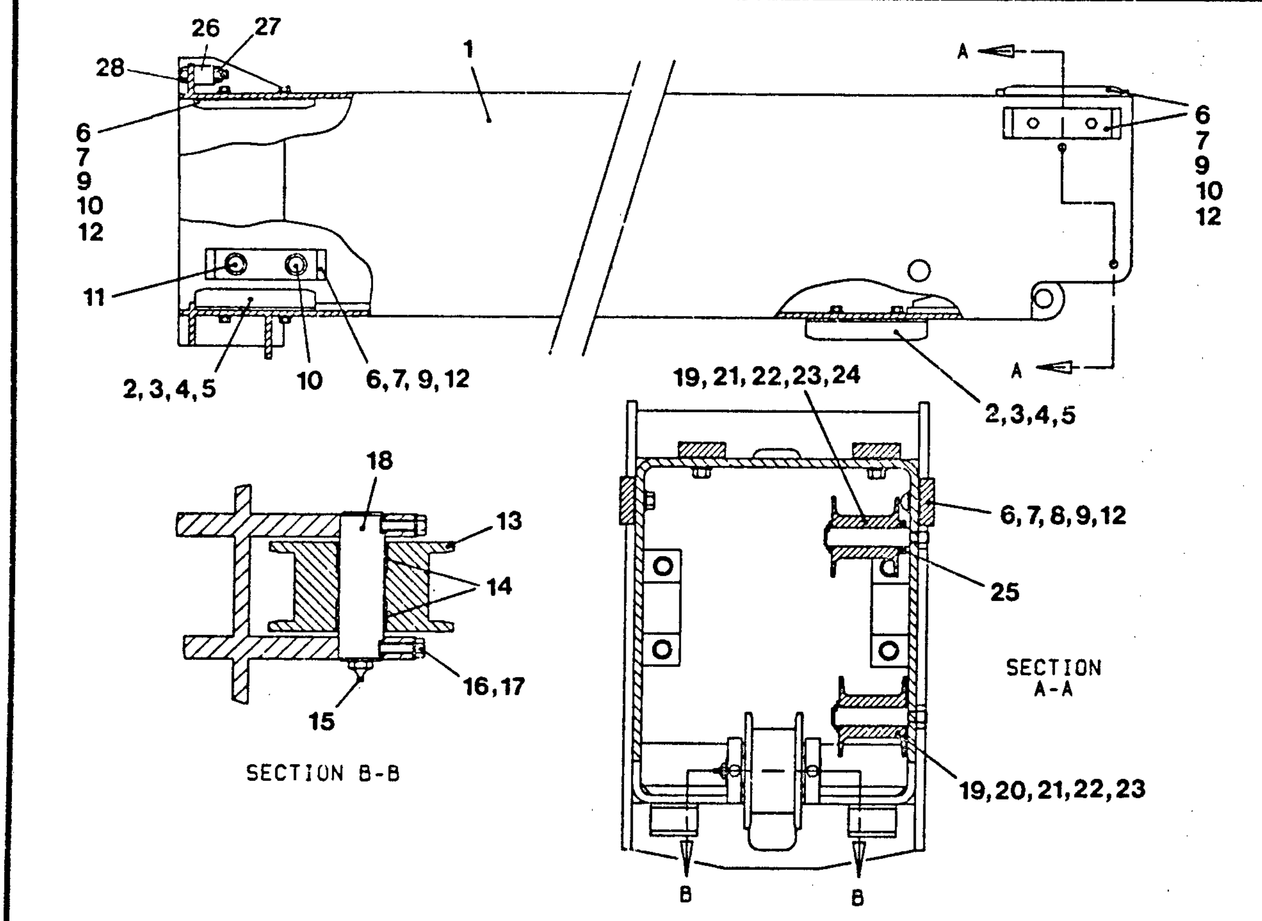
P985889 | Y
REV000

985889 No.1 BOOM SECTION GRP (WITH COMPENSATING CYLINDERS)

Part of 985888 Three Section Boom (with Compensating Cylinders)

985845 - PAGE 212, 985843 - PAGE 212, 815728 - PAGE 213.

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	985980	1	NO.2 BOOM SECTION AS
M	2	897344	4	SHIM 5MM
M	3	8T4121	8	WASHER
M	4	8T4195	8	BOLT
Y	5	985845	4	WEAR PAD GP
MB	6	897342	-	SHIM 0.75MM
MB	7	897343	-	SHIM 1.5MM
M	8	6R9245	2	SCREW
M	9	8T4121	16	WASHER
M	10	8T4136	12	BOLT
M	11	8T4196	2	BOLT
Y	12	985843	8	WEAR PAD GP
	13	815738	1	CHAIN PULLEY

NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	14	897346	2	BUSH
	15	3B8489	1	GREASE NIPPLE
M	16	6V7357	2	BOLT
M	17	8T4205	2	WASHER
	18	986001	1	SHAFT
M	19	3B4624	2	SPLIT PIN
	20	838627	1	ROLLER PIN
M	21	897325	2	ROLLER PULLEY
M	22	8T4123	2	WASHER
	23	6V7687	2	NUT
	24	897326	1	ROLLER PIN
	25	908395	1	WASHER
A	26	816344	2	SPACER
AM	27	8T4133	2	NUT
AM	28	8T6466	2	BOLT

B - USE AS REQUIRED
M - METRIC PART

Y - SEPARATE ILLUSTRATION
A - NOT PART OF THIS GROUP

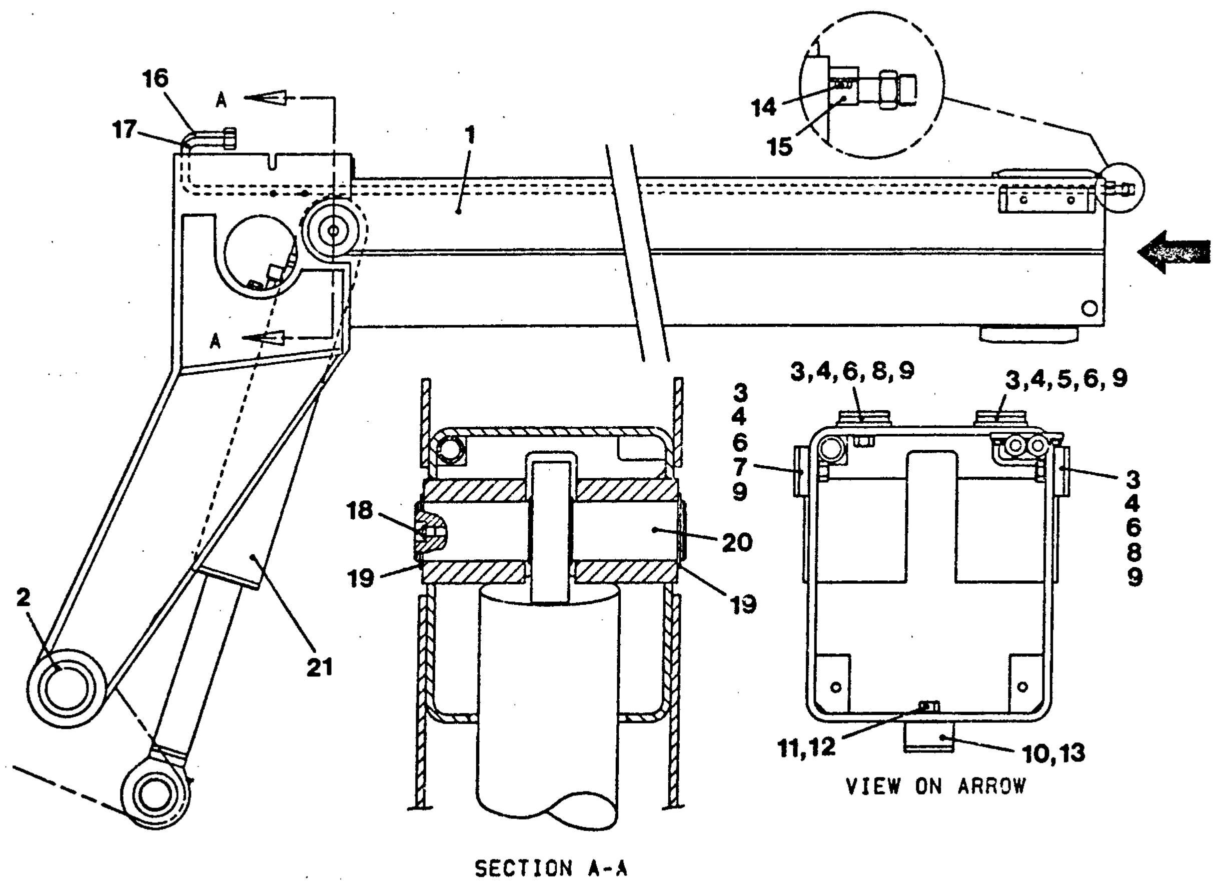
P985979 Y
REV002

985979 No.2 BOOM SECTION GROUP

Part of 985888 Three Section Boom (with Compensating Cylinders)

985845 - PAGE 212, 985843 - PAGE 212.

BOOM AND FORKS



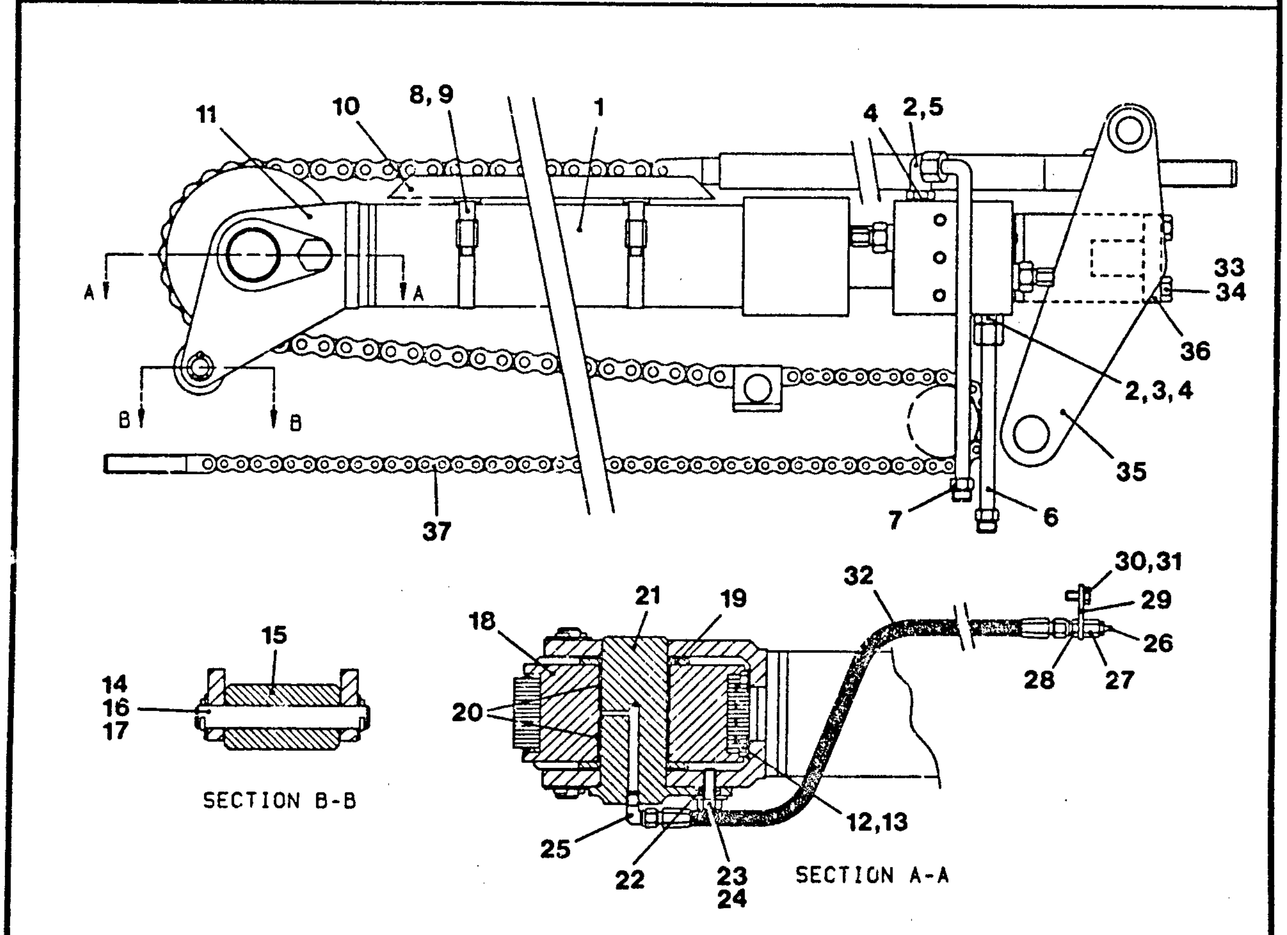
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	986071	1	BOOM HEAD SECTION AS	M	12	8T4196	2	BOLT
M	2	897354	4	BUSH	Y	13	985845	1	WEAR PAD GP
MB	3	897342	-	SHIM 0.75MM	M	14	7X2619	2	BOLT
MB	4	897343	-	SHIM 1.5MM		15	815948	2	PIPE CLIP
M	5	897942	2	SCREW		16	837864	1	STEEL PIPE AS
M	6	8T4121	8	WASHER		17	837865	1	STEEL PIPE AS
M	7	8T4136	2	BOLT		18	3B8489	1	GREASE NIPPLE
M	8	8T4137	4	BOLT	M	19	5K4627	2	SNAP RING
Y	9	985843	4	WEAR PAD GP		20	837398	1	SHAFT
M	10	897344	1	SHIM 5MM	NSSY	21	837931	1	FORK LEVEL GP
M	11	8T4121	2	WASHER					

B - USE AS REQUIRED
NSS - NOT SERVICED
M - METRIC PART
Y - SEPARATE ILLUSTRATION

P986070
REV000

986070 BOOM HEAD SECTION
Part of 985888 Three Section Boom (with Compensating Cylinders)
985843 - PAGE 212, 985845 - PAGE 212, 837931 - PAGE 203.

BOOM AND FORKS



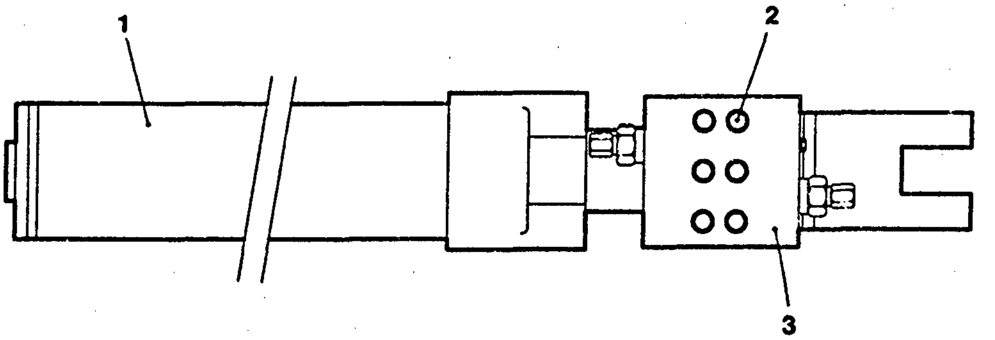
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	837992	1	TELESCOPING CYLINDER GP	M	20	897335	2	BUSH
	2	3D2824	2	O RING		21	897336	1	SHAFT
	3	6V8713	1	ADAPTOR		22	897338	1	SLEEVE
	4	7J9108	2	O RING	M	23	8T4136	1	BOLT
	5	8T0404	1	ELBOW	M	24	8T4222	1	WASHER
	6	986044	1	STEEL PIPE AS		25	2N1287	1	ELBOW
	7	986045	1	STEEL PIPE AS		26	3B8489	1	GREASE NIPPLE
	8	5P0599	5	HOSE CLAMP		27	4U1697	1	ADAPTOR
	9	815551	5	RUBBER STRIP		28	5B3254	1	NUT
	10	986038	1	CHAIN TRAY AS		29	816186	1	BRACKET
	11	815732	1	BRACKET AS	M	30	8T4200	1	BOLT
M	12	8T4224	4	WASHER	M	31	8T4224	1	WASHER
M	13	8T7547	4	BOLT		32	986043	1	PIPE AS
M	14	3B4624	2	SPLIT PIN	M	33	6V5685	4	BOLT
	15	897324	1	ROLLER	M	34	6V8765	4	WASHER
	16	897334	1	SHAFT		35	986032	1	CYLINDERANCHOR AS
M	17	8T3282	2	WASHER		36	986037	1	KEEP PLATE
	18	815733	1	CHAIN PULLEY	Y	37	986027	1	CHAIN GP
	19	815734	2	SPACER					

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P837991 Y
REV000

837991 TELESCOPING GROUP
Part of 985888 Three Section Boom Group (with Compensating Cylinders)
837992 - PAGE 200, 986027 - PAGE 202.

BOOM AND FORKS



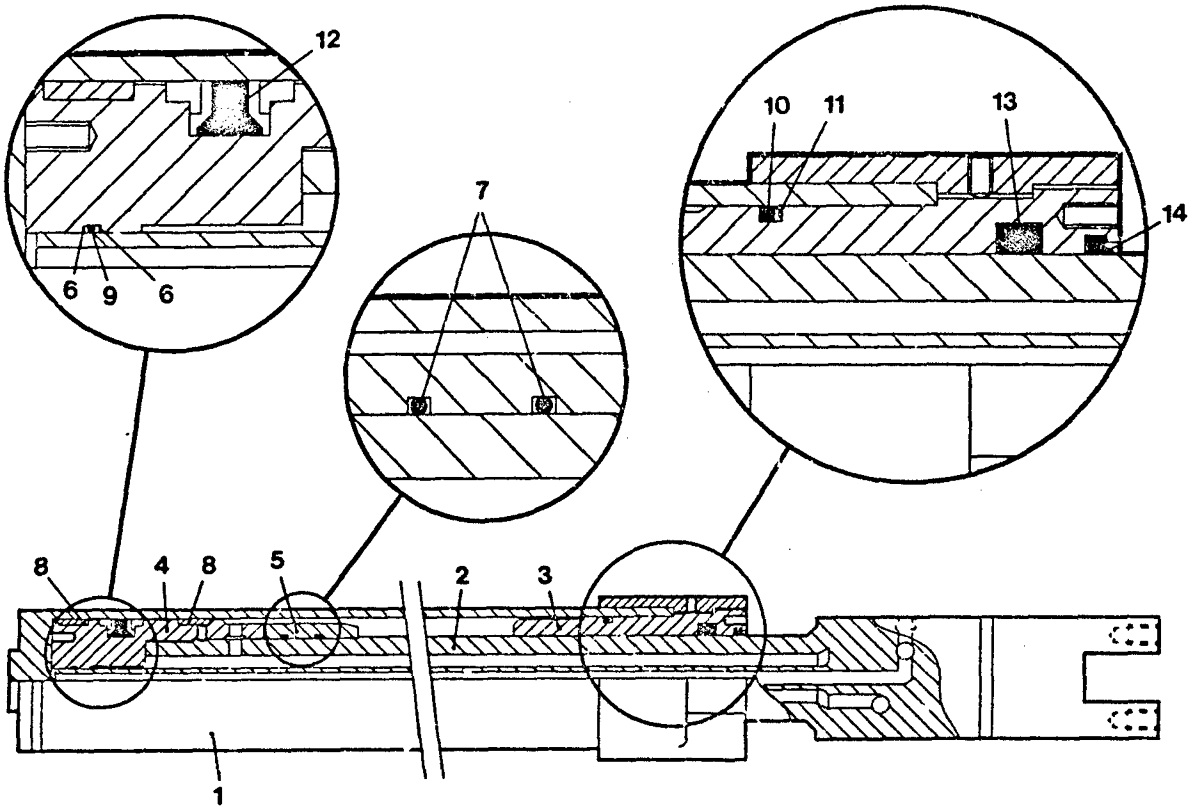
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	985970	1	TELESCOPING CYLINDER					
M	2	6V5195	6	CAPSCREW					
Y	3	897300	1	COUNTERBALANCE LOCKVALVE					

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P837992 Y
REV000

837992 TELESCOPING CYLINDER GROUP
Part of 837991 Telescoping Group
985970 - PAGE 201. 897300 - PAGE 171.

BOOM AND FORKS

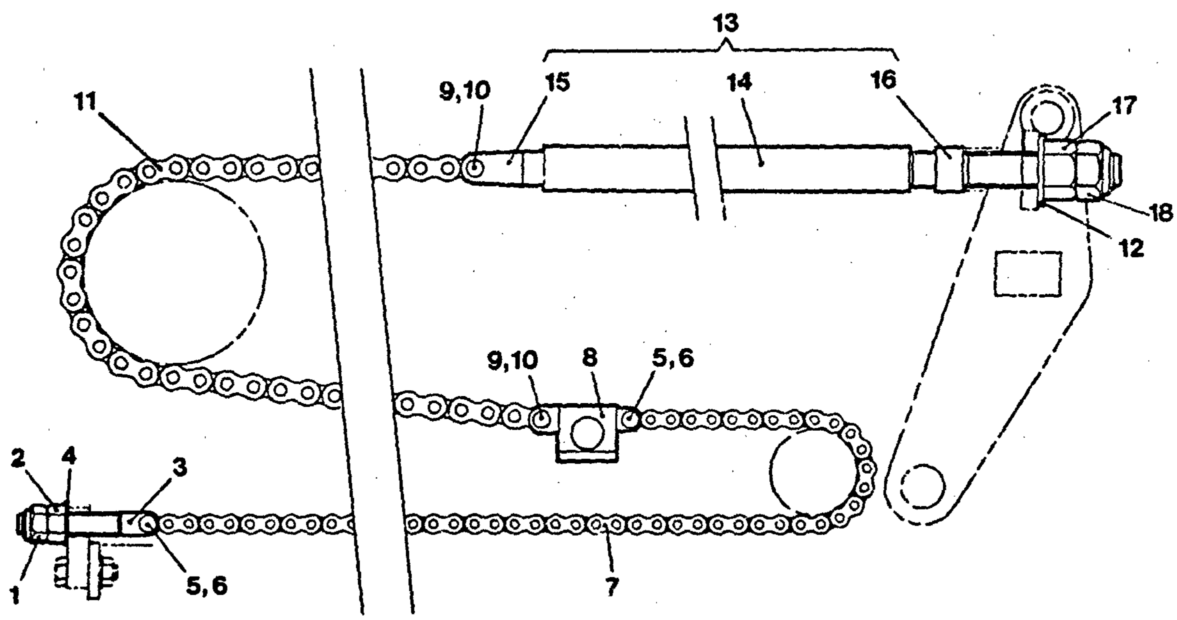


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	510528	1	CYLINDER AS
	2	510529	1	PISTON ROD AS
	3	510530	1	GLAND
	4	510531	1	PISTON
	5	510532	1	SPACER
		897459	1	SEAL KIT
	6	510550	2	RING
	7	510551	2	O RING
	8	838512	2	RING
	9	838513	1	O RING
	10	838515	1	O RING
	11	838516	1	RING
	12	897448	1	SEAL
	13	897454	1	SEAL
	14	897458	1	SEAL

P985970 Y
REV002

985970 TELESCOPING RAM GROUP
Part of 837992 Telescoping Cylinder GP.

BOOM AND FORKS



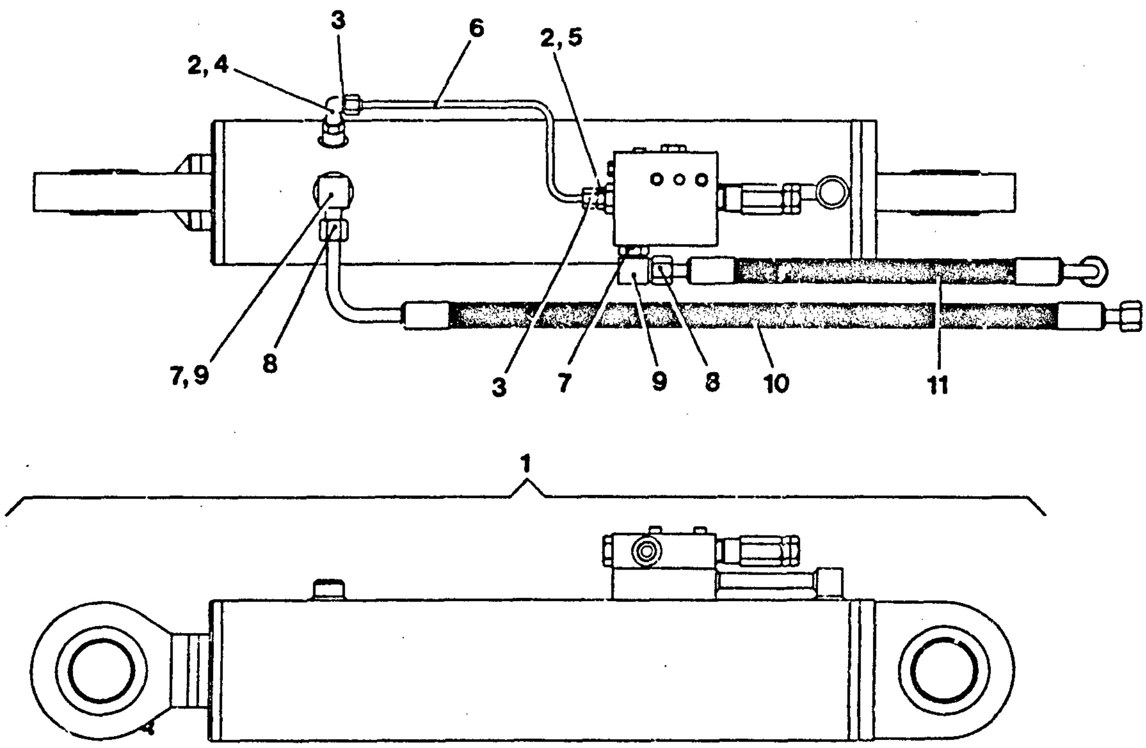
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V7688	1	NUT		10	815755	2	ANCHOR PIN
M	2	6V7742	1	NUT		11	986029	1	EXTENSION CHAIN
	3	815750	1	CHAIN SHACKLE	M	12	3S7023	1	WASHER
M	4	8T3282	1	WASHER		13	815756	1	ANCHOR ROD GP
	5	3B4605	4	SPLIT PIN		14	NSS	1	TUBE
	6	815752	2	ANCHOR PIN		15	NSS	1	SHACKLE
	7	986028	1	RETRACTION CHAIN		16	NSS	1	ANCHOR ROD
	8	815753	1	CHAIN ANCHOR	M	17	8T1583	1	NUT
	9	3B4611	4	SPLIT PIN	M	18	8T5065	1	NUT

M - METRIC PART
NSS - NOT SERVICED

P986027 Y
REV001

986027 CHAIN GROUP
Part of 837991 Telescoping Group.

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	837932	1	FORK LEVEL CYLINDER GP		7	3K0360	2	O RING O.R.B.
	2	3J7354	2	O RING O.R.B.		8	6V8398	2	O RING O.R.F.S.
	3	4J5477	2	O RING O.R.F.S.		9	6V8625	2	ELBOW
	4	6V8628	1	ELBOW		10	837934	1	HOSE AS
	5	6V8647	1	ADAPTOR		11	837935	1	HOSE AS
	6	837933	1	STEEL PIPE AS					

Y - SEPARATE ILLUSTRATION

P837931 Y

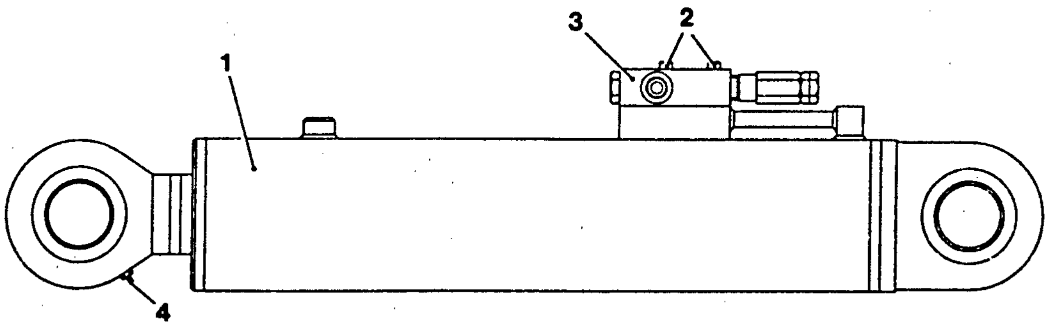
REV000

837931 FORK LEVEL GROUP

Part of 986070 Boom Head Section Group

837932 - PAGE 204.

BOOM AND FORKS



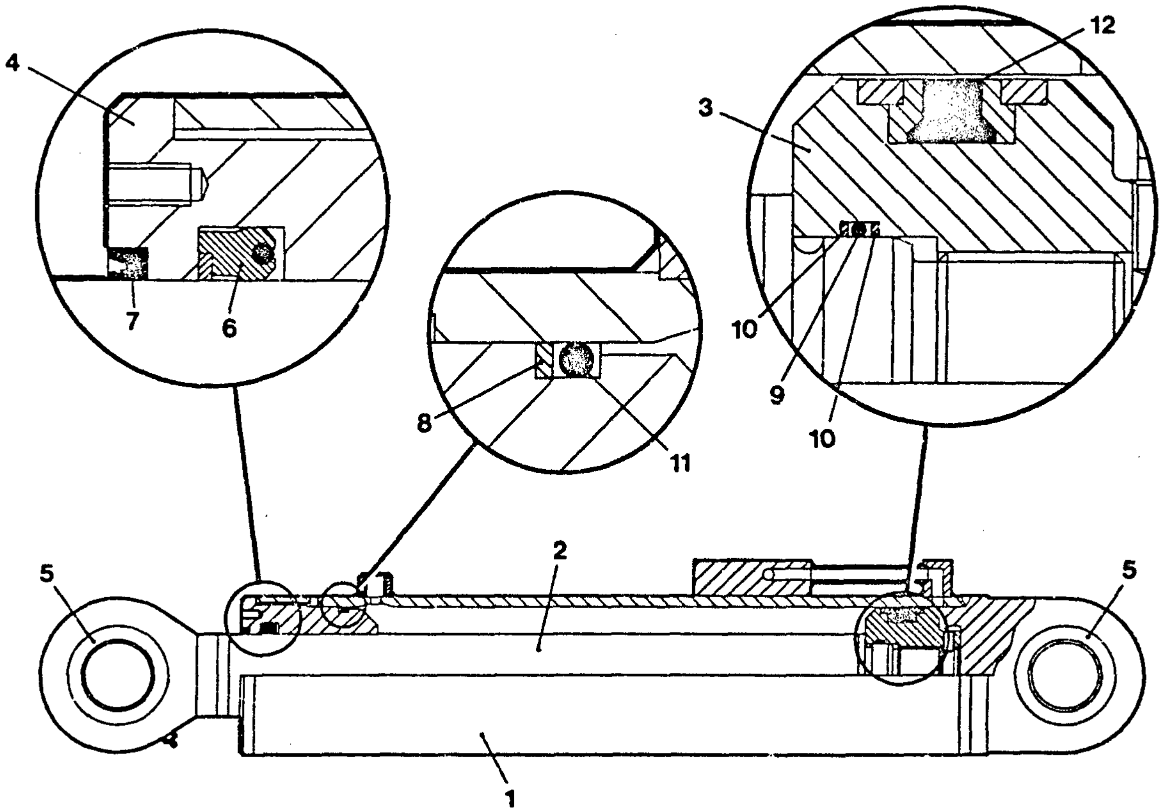
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	985755	1	FORK LEVEL CYLINDER					
M	2	6V5193	2	CAPSCREW					
Y	3	897299	1	OVERCENTRE/LOCKVALVE					
	4	3B8489	1	GREASE NIPPLE					

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P837932 Y
REV000

837932 FORK LEVEL CYLINDER GROUP
Part of 837931 Fork Level Group
985755 - PAGE 205, 897299 - PAGE 172.

BOOM AND FORKS

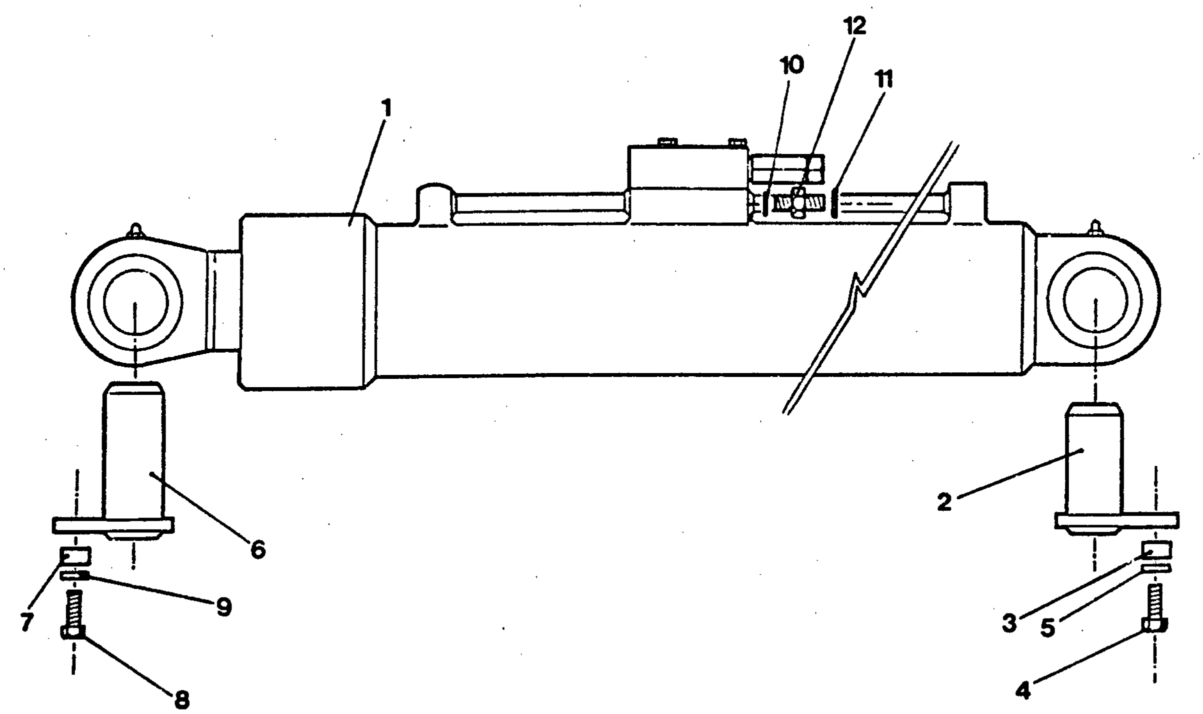


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	510552	1	CYLINDER AS			6R7779	1	SEAL KIT
	2	510553	1	PISTON ROD AS		6	510557	1	SEAL
	3	510554	1	PISTON		7	510558	1	WIPER
	4	510555	1	GLAND		8	510559	1	RING
	5	510556	2	SPHERICAL BEARING		9	510560	1	O RING
						10	510561	2	RING
						11	838509	1	O RING
						12	897450	1	SEAL

P985755 Y
REV001

985755 FORK TILT RAM GP
Part of 837932 Fork Level Cylinder GP

BOOM AND FORKS



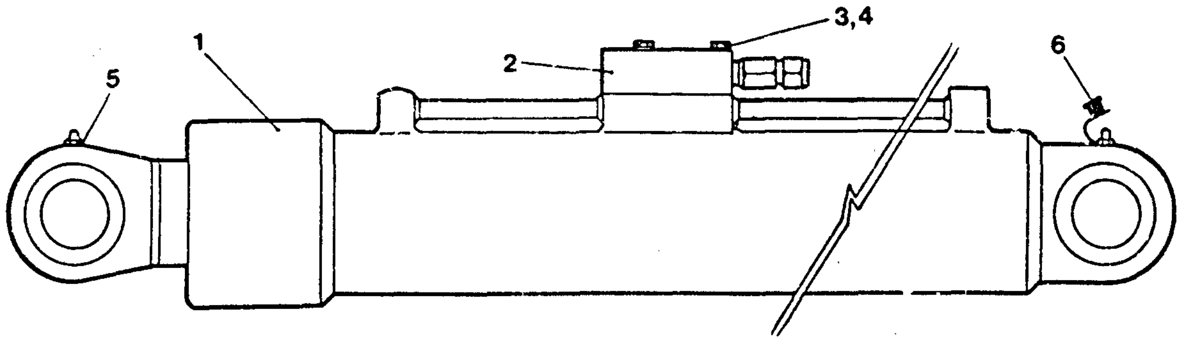
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	838021	1	BOOM RAISE RAM GROUP		7	897338	1	SLEEVE
	2	815554	1	PIN (CHASSIS)	M	8	8T4137	1	BOLT
	3	897338	1	SLEEVE	M	9	8T4222	1	WASHER
M	4	8T4137	1	BOLT		10	2M9780	2	O RING O.R.B
M	5	8T4222	1	WASHER		11	6V8398	2	O RING SEAL O.R.F.S
	6	815555	1	PIN (BOOM)		12	6V8638	2	ADAPTOR

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P838022 Y
REV 000

838022 BOOM RAISE GROUP
838021 - PAGE 207.

BOOM AND FORKS

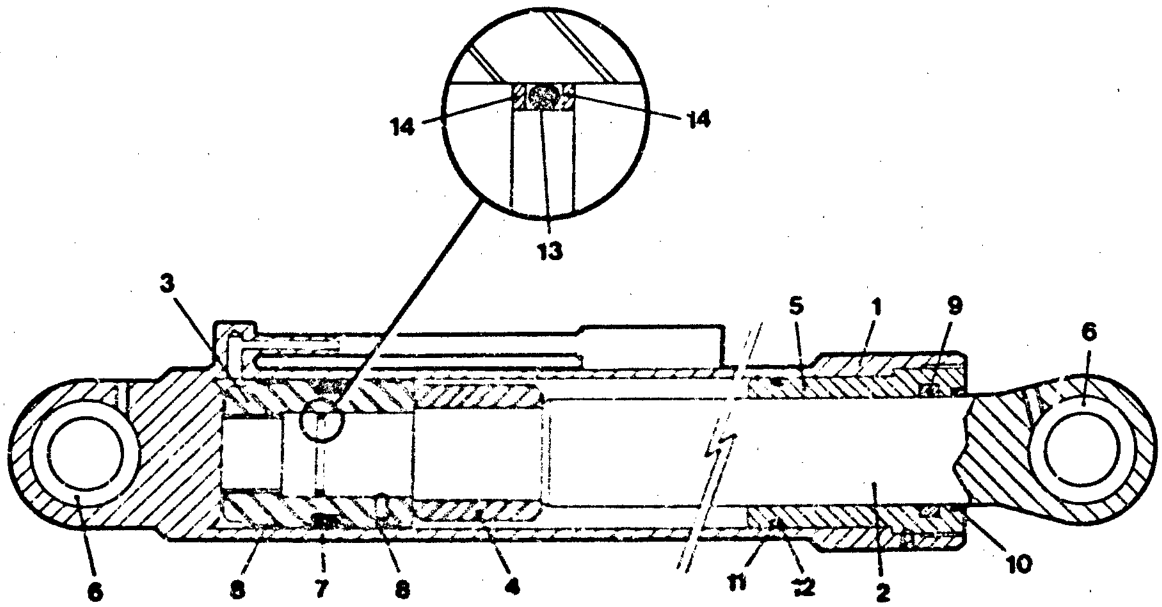


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
					Y	1	838020	1	BOOM RAISE RAM
					Y	2	897301	1	OVERCENTRE/LOCKVALVE
					M	3	8T4224	4	WASHER
					M	4	8T6912	4	BOLT
						5	3B8489	2	GREASE NIPPLE
						6	5U7151	2	COVER

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P838021
REV 000

838021 BOOM RAISE RAM GROUP
Part of 838022 Boom Raise Group
838020 - PAGE 208, 897301 - PAGE 170.

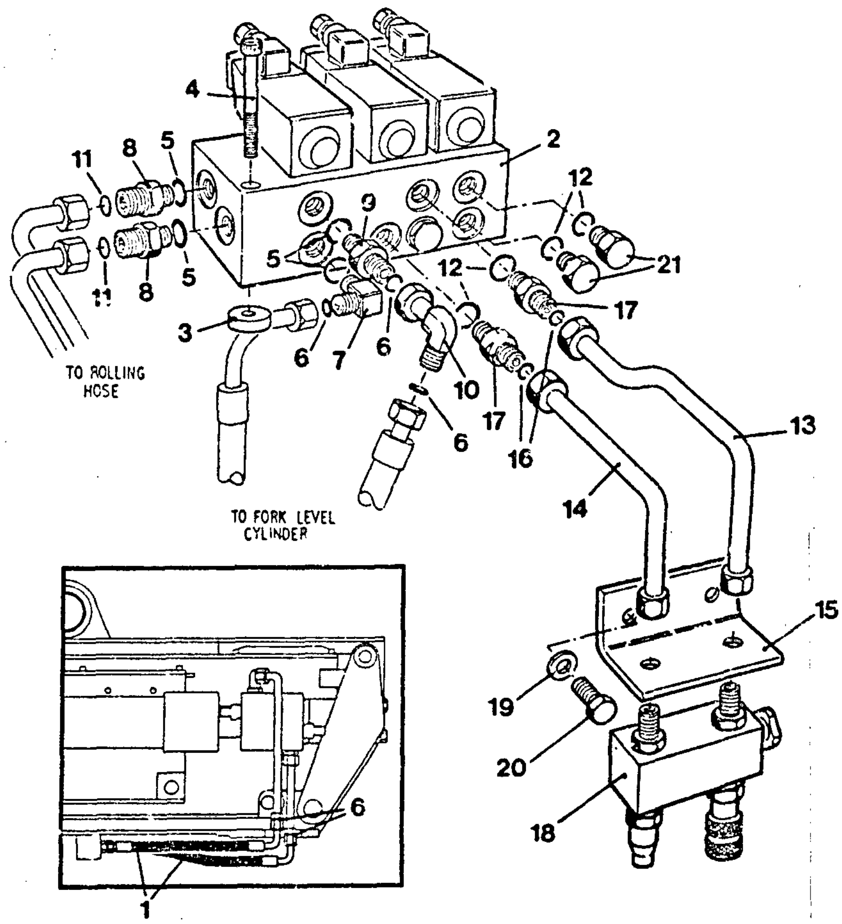


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	510522	1	CYLINDER AS			6R7778	1	SEAL KIT
	2	510523	1	PISTON ROD AS		7	510514	1	SEAL
	3	510524	1	PISTON		8	510515	2	RING
	4	510525	1	STOP TUBE		9	510516	1	SEAL
	5	510526	1	GLAND		10	510517	1	WIPER
	6	510527	2	SPHERICAL BEARING		11	510518	1	O RING
						12	510519	1	RING
						13	510520	1	O RING
						14	510521	2	RING

P838020 Y
REV001

838020 BOOM RAISE RAM GROUP
Part of 838021 Boom Raise Ram GP.

BOOM AND FORKS



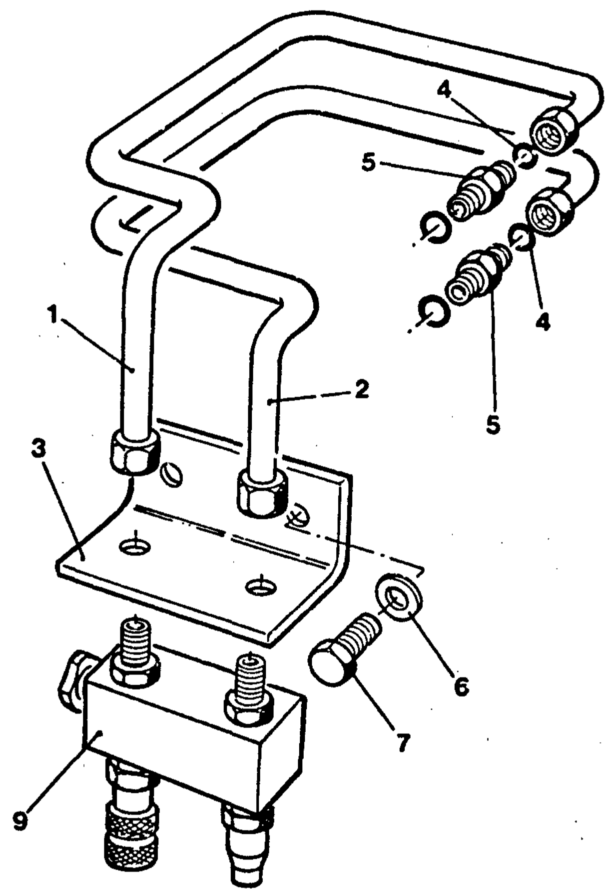
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	838011	2	HOSE AS
Y	2	897303	1	CETOP 3 CONTROL POLYHYDRON
	3	897365	3	SPECIAL WASHER
M	4	8T2397	3	CAP SCREW
	5	3K0360	4	O RING
	6	6V8398	3	O RING
	7	6V8625	1	ELBOW
	8	6V8632	2	ADAPTOR
	9	6V8639	1	ADAPTOR
	10	6V9851	1	SWIVEL ELBOW
	11	7J9108	2	O RING
	12	3J1907	4	O RING
	13	6R8926	1	STEEL PIPE AS
	14	6R8927	1	STEEL PIPE AS
	15	6R8928	1	ADAPTOR BRACKET
	16	6V8397	2	O RING
	17	6V8636	2	ADAPTOR
Y	18	8Q2116	1	PRESSURE BALANCE VALVE G.P.
M	19	8T4121	2	WASHER
M	20	8T4137	2	BOLT
	21	9S4191	2	PLUG

M - METRIC PART
Y - SEPARATE ILLUSTRATION
NSS - NOT SERVICED

P838010 Y
REV002

838010 BOOM HYDRAULIC GROUP
Part of 985888 Three Section Boom (with Compensating Cylinders)
897303 - PAGE 211, 8Q2116 - PAGE 211.

BOOM AND FORKS (AN ATTACHMENT)



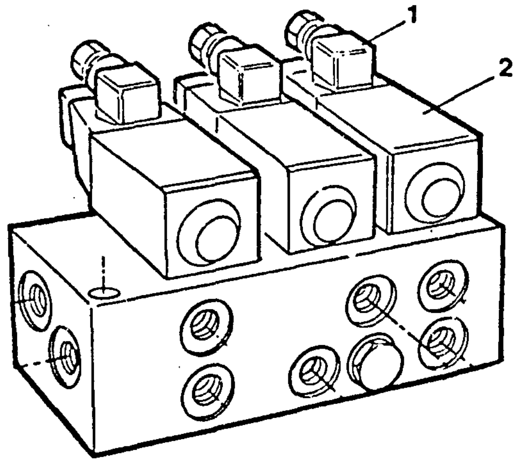
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R8924	1	STEEL PIPE AS	M	6	8T4121	2	WASHER
	2	6R8925	1	STEEL PIPE AS	M	7	8T4137	2	BOLT
	3	6R8928	1	ADAPTOR BRACKET	Y	9	8Q2116	1	PRESSURE BALANCE VALVE G.P.
	4	6V8397	2	O RING		F	6R7701	1	AUX. 2 ELECTRICAL GROUP
	5	6V8636	2	ADAPTOR	NSSY	F	975527	1	FILM - BOOM CONTROL

M - METRIC PART Y - SEPARATE ILLUSTRATION
NSS - NOT SERVICED F - NOT SHOWN

P838012 Y
REV004

838012 AUXILIARY 2 SERVICE GROUP
6R7701 - PAGE 282, 8Q2116 - PAGE 211.

BOOM AND FORKS



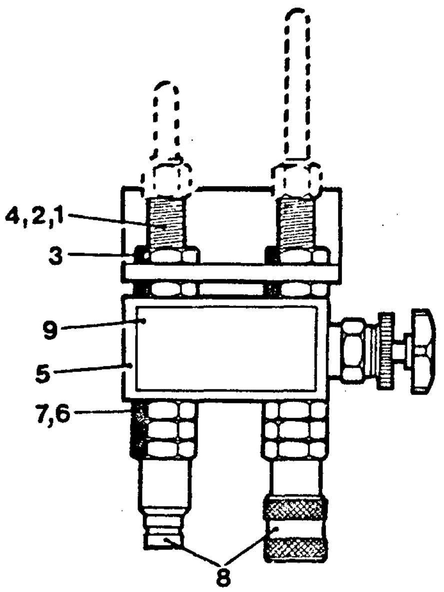
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	816316	3	CONNECTOR
	2	816364	3	SOLENOID COIL
F	-	816365	1	SEAL KIT

F - NOT SHOWN

P897303 Y
REV 002

897303 CETOP 3 CONTROL VALVE
Part of 838010 Boom Hydraulics Group

BOOM AND FORKS (AN ATTACHMENT)

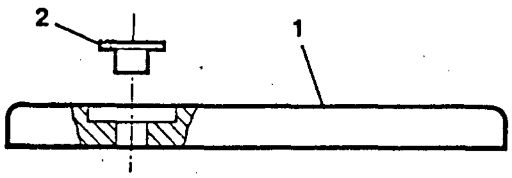


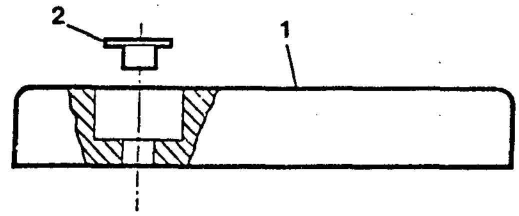
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6V8397	2	O. RING O.R.F.S.
	2	897702	2	BULKHEAD ADAPTOR
	3	6V9168	2	BULKHEAD NUT
	4	3J1907	4	O. RING O.R.B.
	5	6R9316	1	VALVE MANIFOLD
	6	8Q2118	2	ADAPTOR
	7	3K0360	2	O. RING O.R.B.
	8	8Q2117	1	COUPLING - QUICK RELEASE
	9	510510	1	DECAL

P8Q2116 Y
REV000

8Q2116 PRESSURE BALANCE GROUP
Part of 83010 Boom Hydraulic Group and 838012 Aux 2 Services Group

BOOM AND FORKS





985843

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	985844	1	WEAR PAD
	2	985509	2	INSERT

P985843 Y
REV 000

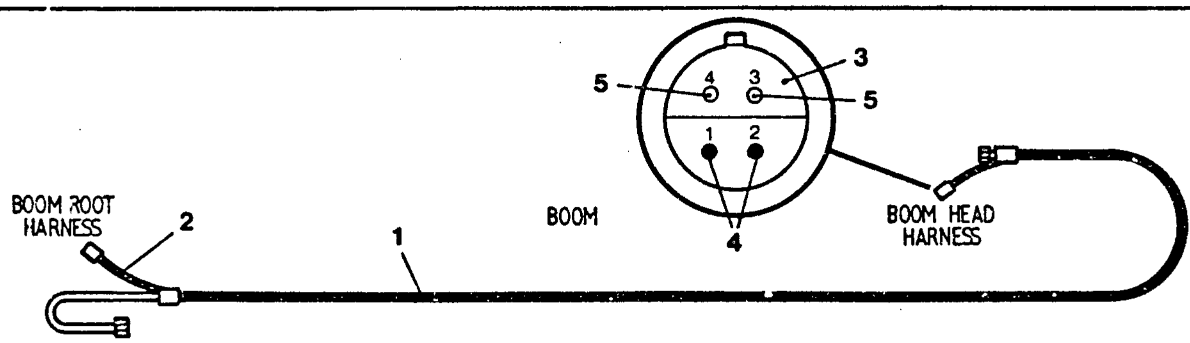
985845

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	985846	1	WEAR PAD
	2	985509	2	INSERT

P985845 Y
REV 000

985843 AND 985845 WEAR PAD GROUPS
Part of 985889, 985979, 986070 Boom Services Groups.

BOOM AND FORKS

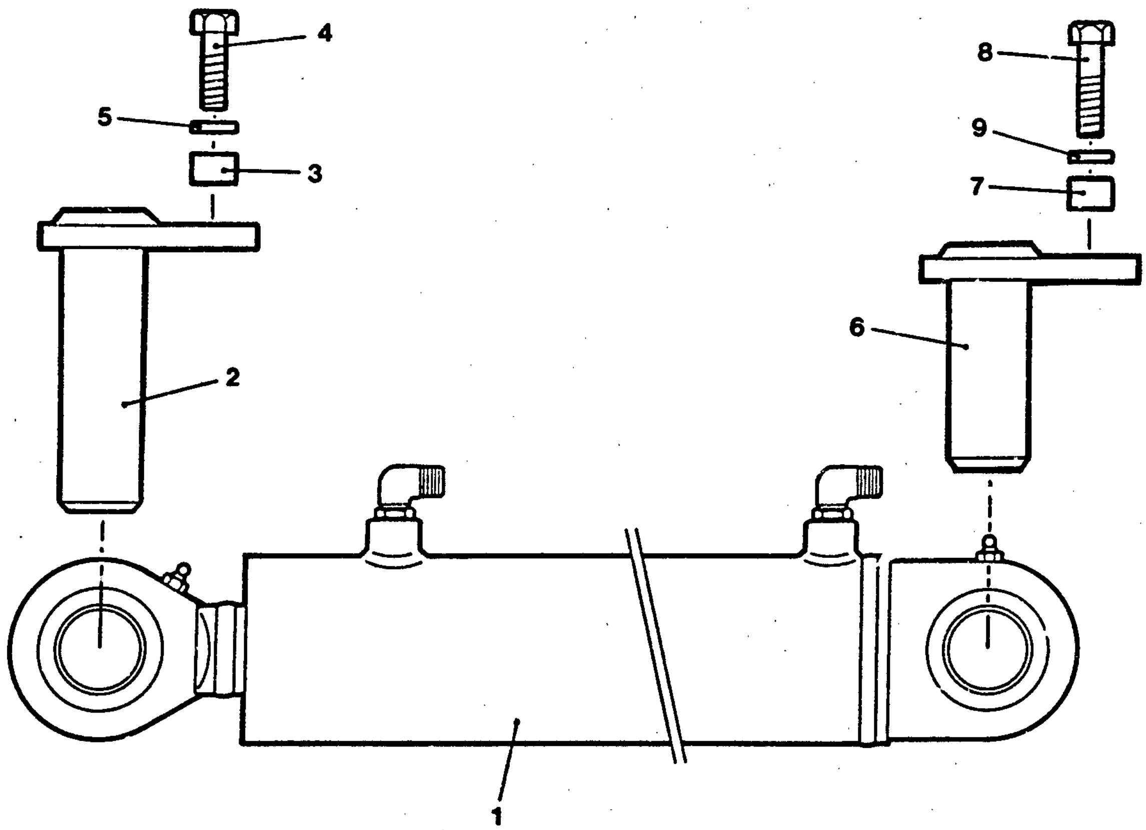


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815795	1	ROLLING HOSE					
	2	816355	1	HARNESS ASSEMBLY					
	3	7N8205	1	HOUSING					
	4	7N7780	2	PIN					
	5	7N7779	2	SOCKET					

P815728 Y
REV000

815728 ROLLING HOSE GROUP
Part of 985889 No 1 Boom Section Group (with Compensating Cylinders)

BOOM AND FORKS



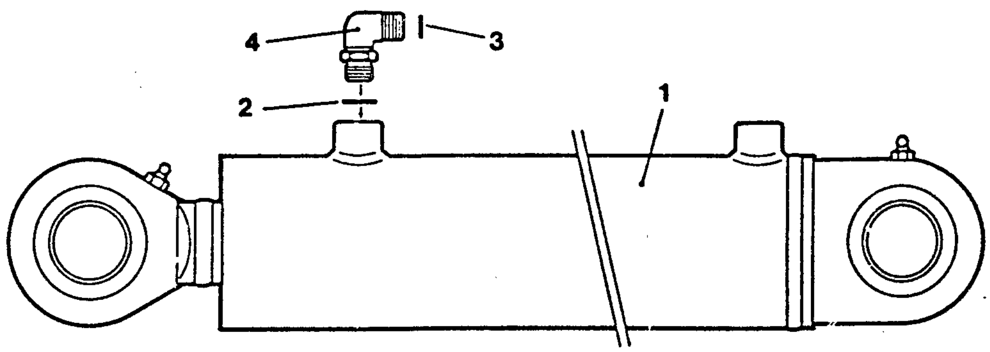
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	838023	2	COMPENSATING CYLINDER GP		6	838033	2	PIN AS
	2	838034	2	PIN AS		7	897338	2	SLEEVE
	3	897338	2	SLEEVE	M	8	8T4195	2	BOLT
M	4	8T4195	2	BOLT	M	9	8T4222	2	WASHER
M	5	8T4222	2	WASHER					

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P838024 Y
REV000

838024 COMPENSATING GROUP
838023 - PAGE 215.

BOOM AND FORKS

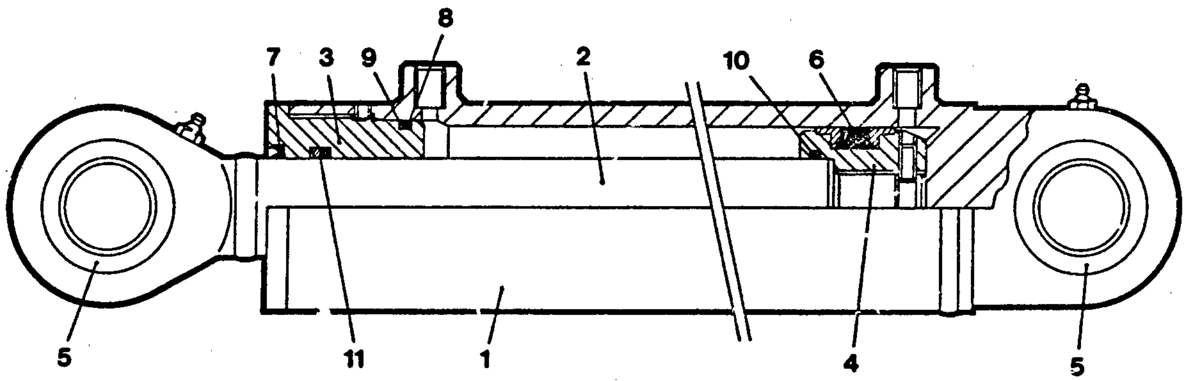


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	985971	1	COMPENSATING CYLINDER					
	2	3J1907	2	O RING					
	3	6V8397	2	O RING					
	4	6V8724	2	ELBOW					

Y - SEPARATE ILLUSTRATION

P838023 Y
REV000

838023 COMPENSATING CYLINDER GROUP
Part of 838024 Compensating Group
985971 - PAGE 216



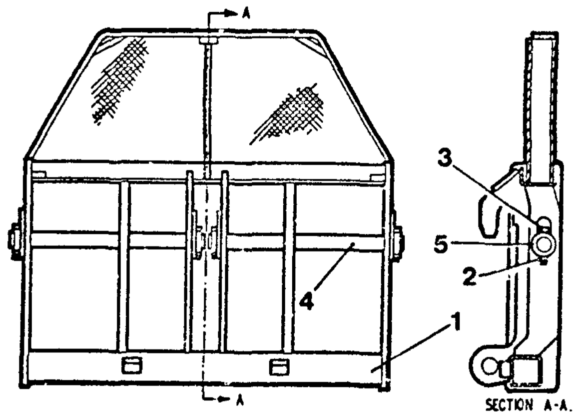
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	510562	1	CYLINDER AS			6R7780	1	SEAL KIT
	2	510563	1	PISTON ROD AS		6	510567	1	SEAL
	3	510564	1	GLAND		7	510568	1	WIPER
	4	510565	1	PISTON		8	510569	1	O RING
	5	510566	2	SPHERICAL BEARING		9	510570	1	RING
						10	510571	1	SEAL
						11	898160	1	SEAL

P985971 Y

REV001

985971 COMPENSATING RAM GP
Part of 838023 Compensating Ram GP

BOOM AND FORKS



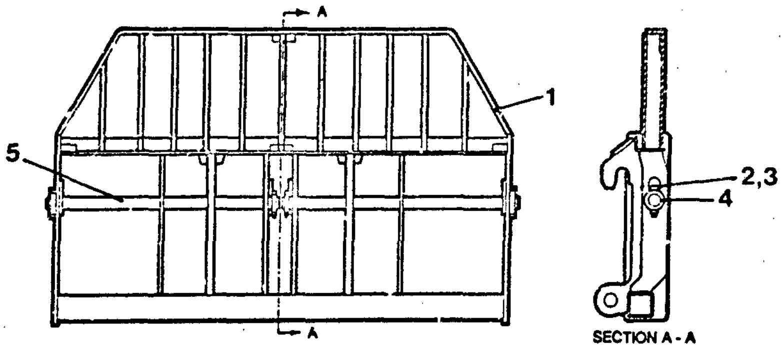
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	838626	1	FORK CARRIAGE AS.
M	2	6V9189	4	NYLOC NUT
M	3	7X2538	4	BOLT
	4	816112	2	SHAFT
	5	816113	4	COLLAR

M - METRIC PART

P838625 Y
REV 000

838625 FORK CARRIAGE GROUP

BOOM AND FORKS (AN ATTACHMENT)



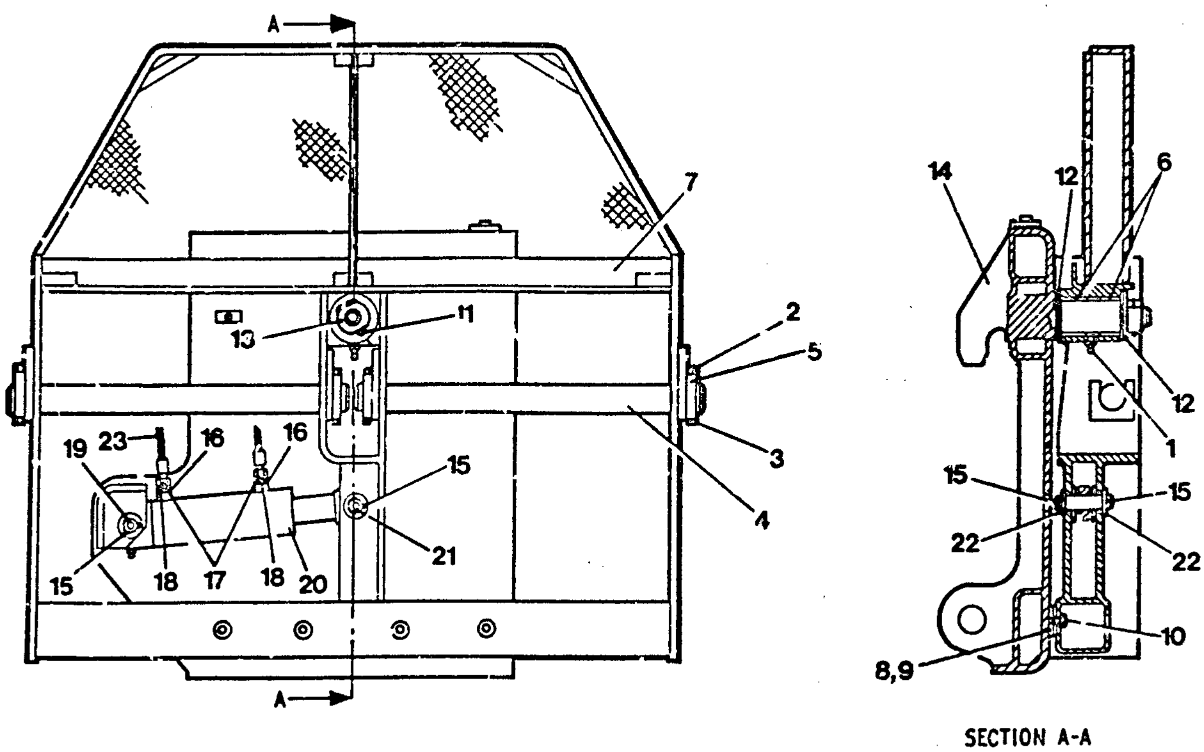
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7762	1	FRAMERS FORK CARRIAGE AS					
M	2	6V5223	4	BOLT					
M	3	6V9189	4	NYLOC NUT					
	4	816113	4	COLLAR					
	5	844230	2	SHAFT FORK CARRIER					

M - METRIC PART

P838822 Y
REV000

838822 FRAMERS FORK CARRIAGE GROUP

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3B8489	1	GREASE NIPPLE
M	2	6V5223	4	BOLT
M	3	6V9189	4	NYLOC NUT
	4	816112	2	SHAFT
	5	816113	4	COLLAR
M	6	816208	2	BUSH
	7	838651	1	FORK CARRIAGE AS.
	8	897310	2	BOOM WEAR PAD
B	9	897342	1	SHIM
M	10	8T3137	4	BOLT
	11	3B4636	1	SPLIT PIN
	12	816210	2	THRUST WASHER
M	13	816212	1	NUT-SPECIAL
	14	838649	1	CARRIER AS.
	15	7B1331	4	SPLIT PIN
	16	3J1907	2	O RING
	17	4J5477	2	O RING (ORFS)
	18	816352	2	ADAPTOR
	19	815790	1	PIN
Y	20	816164	1	HYDRAULIC RAM-FORK ROTATE
	21	844303	1	PIN
M	22	8T4167	4	WASHER
Y	23	8Q2113	1	BOOM HYD. FORK ROTATE GROUP

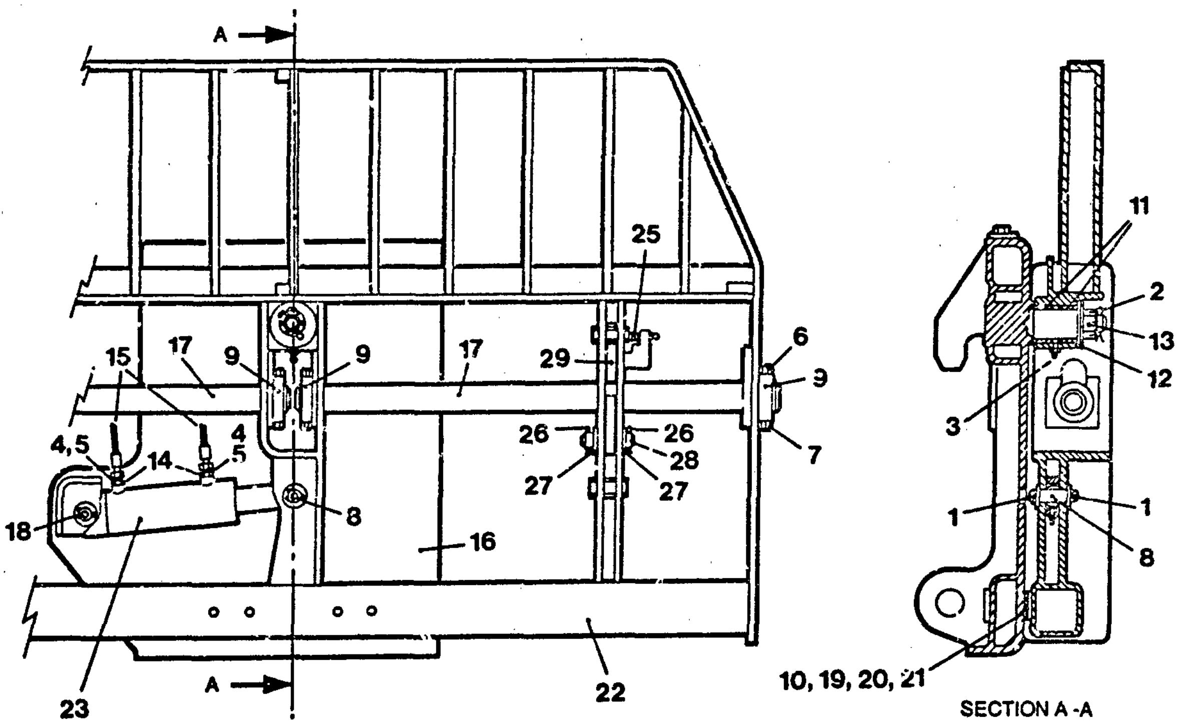
B - USE AS REQUIRED
M - METRIC PART
Y - SEPARATE ILLUSTRATION

P838669 Y
REV 004

838669 ROTATE FORK CARRIAGE GROUP

816164 - PAGE 221, 8Q2113 - PAGE 222.

BOOM AND FORKS (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3B4621	4	SPLIT PIN
	2	3B4636	1	SPLIT PIN
	3	3B8489	1	GREASE NIPPLE
	4	3J1907	2	O RING O.R.B.
	5	4J5477	2	O RING O.R.F.S.
M	6	6V5223	4	BOLT
M	7	6V9189	4	NYLOC NUT
	8	815790	1	PIN
	9	816113	4	COLLAR
Y	10	985843	2	WEAR PAD GP
M	11	816208	2	BUSH
	12	816210	2	THRUST WASHER
M	13	816212	1	NUT
	14	816352	2	ADAPTOR
Y	15	8Q2113	1	BOOM HYD. FORK ROTATE GP

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	16	838649	1	CARRIER AS
	17	844230	2	SHAFT - FORK CARRIER
	18	844303	1	PIN
B	19	897342	-	SHIM 0.75MM
M	20	8T4137	4	BOLT
M	21	8T4167	4	WASHER
	22	844190	1	FRAMERS CARRIAGE AS
Y	23	816164	1	HYD RAM - FORK ROTATE
A	25	838978	2	PIN AS
A	26	3B5301	4	SPLIT PIN
A	27	8T4167	4	WASHER
A	28	838939	2	PIN
A	29	844184	2	LATCH PLATE

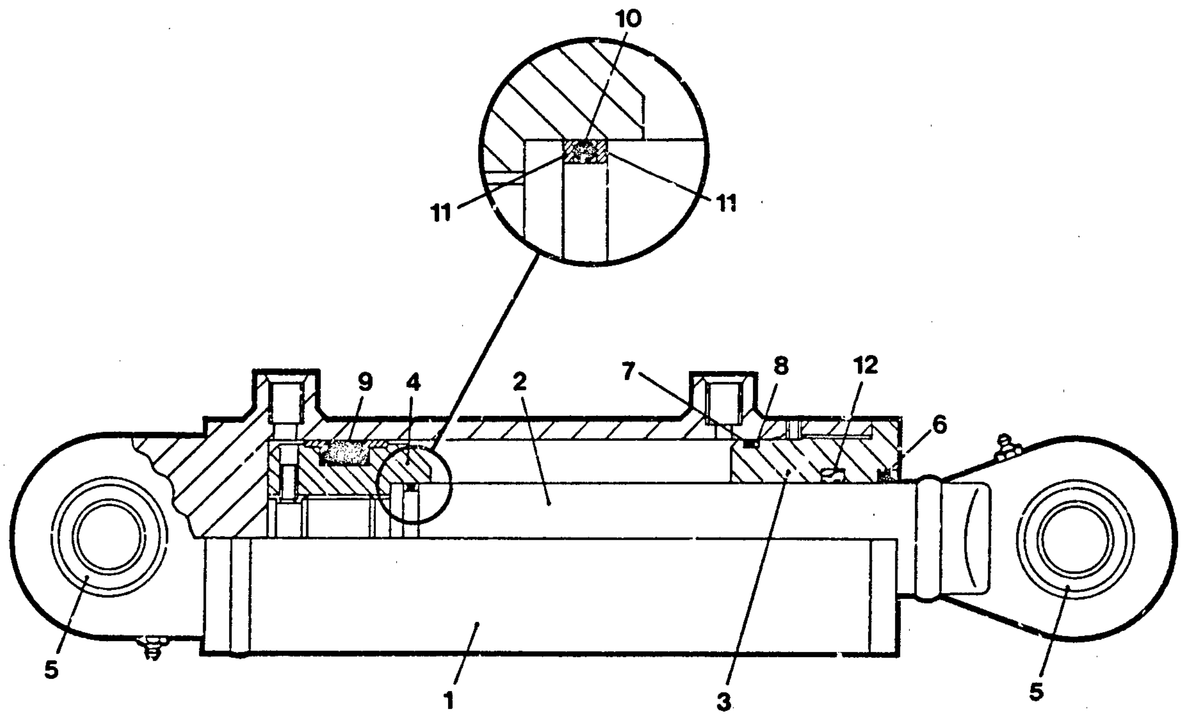
M - METRIC PART
Y - SEPARATE ILLUSTRATION
B - USE AS REQUIRED
A - NOT PART OF THIS GROUP

P838823 Y
REV001

838823 FRAMERS ROTATE - FORK CARRIAGE GROUP

8Q2113 - PAGE 222, 985843 - PAGE 212, 816164 - PAGE 221.

BOOM AND FORKS (AN ATTACHMENT)



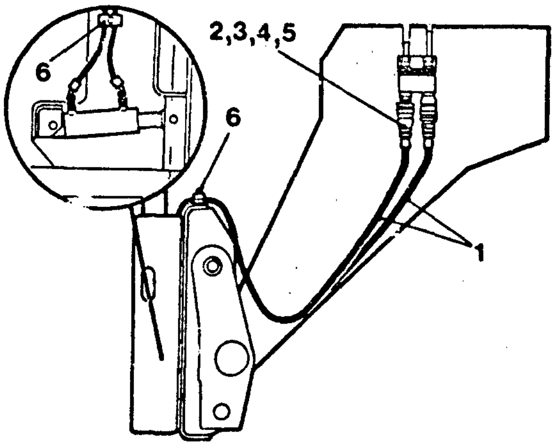
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	5I0572	1	CYLINDER AS
	2	5I0573	1	PISTON ROD AS
	3	5I0574	1	GLAND
	4	5I0575	1	PISTON
	5	975442	2	SPHERICAL BEARING

NOTE	REF NO	PART NUMBER	QTY	PART NAME
		6R7782	1	SEAL KIT
	6	5I0568	1	WIPER
	7	5I0569	1	O RING
	8	5I0570	1	RING
	9	5I0576	1	SEAL
	10	5I0577	1	O RING
	11	5I0578	2	RING
	12	898160	1	SEAL

P816164 Y
REV001

816164 HYD RAM-FORK ROTATE GF
Part of 838823 And 838669 Rotate Carriage Groups

BOOM AND FORKS

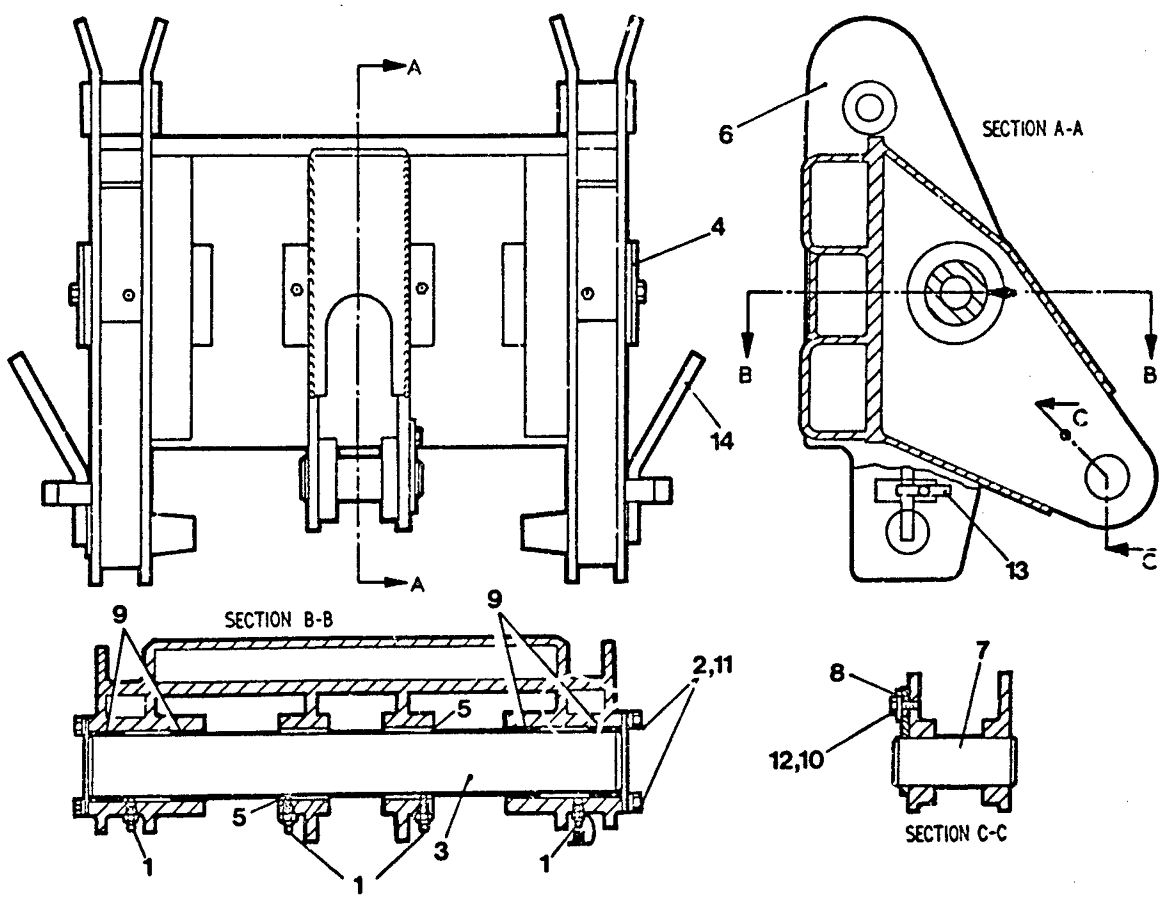


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815874	2	HOSE AS.
	2	8Q2117	1	SELF-SEALING COUPLING
	3	3K0360	2	O. RING O.R.B.
	4	8Q2118	2	ADAPTOR
	5	4J5477	2	O RING (O.R.F.S.)
	6	897614	2	PIPE CLAMP

P8Q2113 Y
REV 000

8Q2113 HYDRAULIC PIPING GROUP - ROTATE FORKS
Part of 838823 AND 838669 Rotate Carriage Groups

BOOM AND FORKS



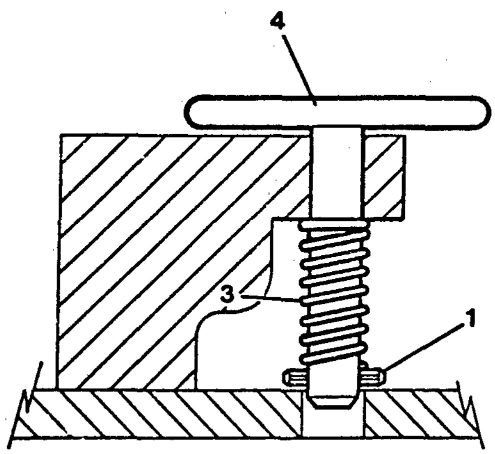
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3B8489	4	GREASE NIPPLE		8	897338	1	SLEEVE
M	2	5C9553	4	BOLT	M	9	897354	4	METRIC BUSH
	3	815572	1	PIVOT SHAFT	M	10	8T4136	1	BOLT
	4	815933	2	END COVER	M	11	8T4205	4	WASHER
M	5	816046	2	BUSH	M	12	8T4222	1	WASHER
	6	838504	1	QUICK HITCH AS.	Y	13	985853	2	PIN RETAINING GROUP
	7	C97328	1	LEVER PIN		14	985858	2	PIN AS.

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P838524 Y
REV 004

838524 QUICK HITCH GROUP
985853 - PAGE 224.

BOOM AND FORKS



SIDE PLATE OF QUICK HITCH

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	985852	1	TENSION PIN
C	--	---------	--	----------
	3	985851	1	SPRING
	4	985850	1	SPRING RETAINER & HANDLE

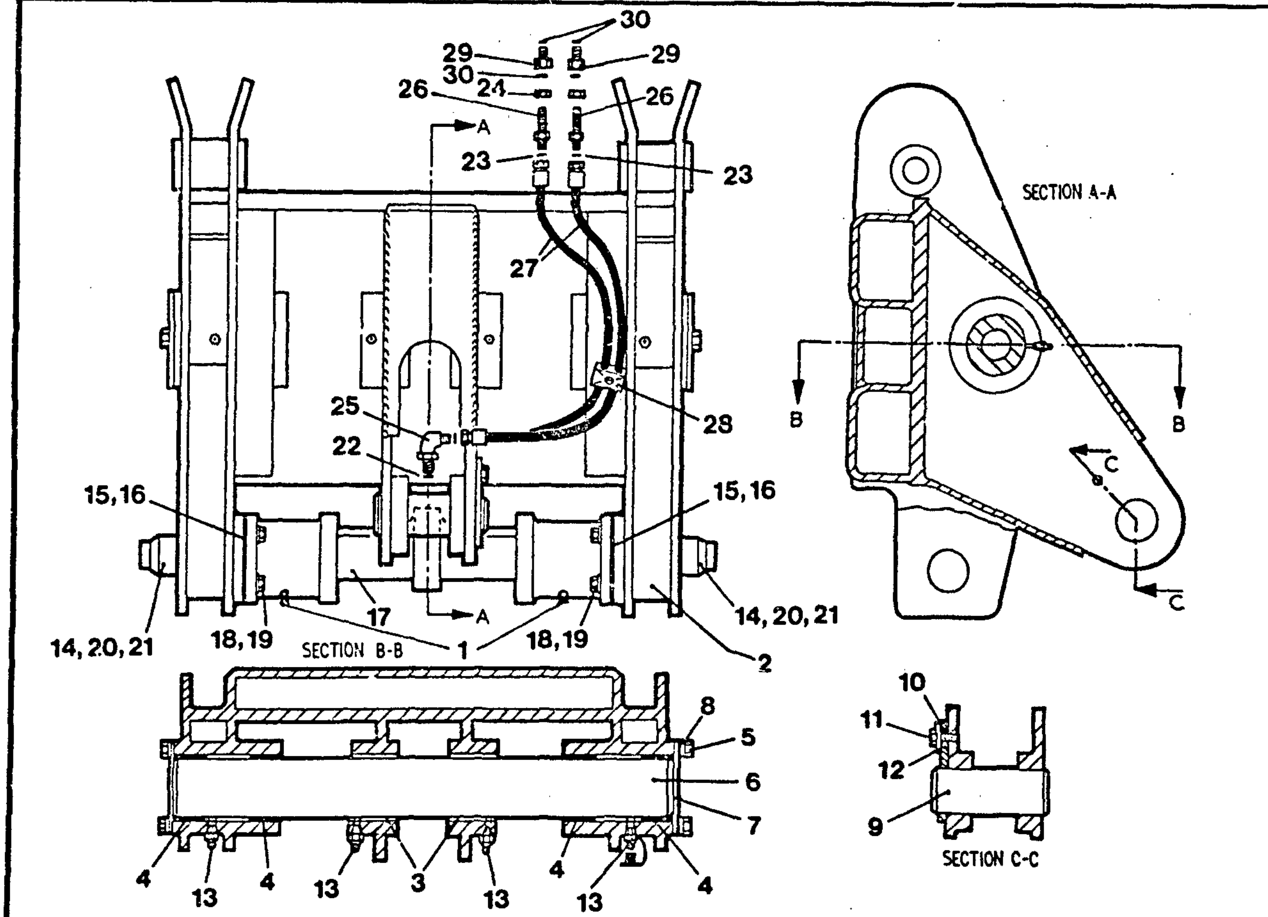
C - INDICATES CHANGE

P985853 Y

REV 002

985853 QUICK HITCH PIN RETAINING GROUP
PART OF 838524 QUICK HITCH GROUP

BOOM AND FORKS (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3B4615	2	SPLIT PIN	Y	17	844105	1	RAM - QUICK HITCH
	2	6R7938	1	HYD QUICK HITCH WELD AS.	M	18	8T4121	8	WASHER
M	3	816046	2	BUSH	M	19	8T4137	8	BOLT
M	4	897354	4	BUSH	M	20	8T4223	2	WASHER
	5	5C9553	4	BOLT	M	21	8T6868	2	BOLT
	6	815572	1	PIVOT SHAFT	YNSS	F	6R7833	1	ELEC. GROUP - HYD. QUICK HITCH
	7	815933	2	END COVER		F	975528	1	FILM - BOOM CONTROL
M	8	8T4205	4	WASHER		22	3J1907	2	O. RING
	9	897328	1	LEVEL LEVER PIN		23	4J5477	4	O. RING SEAL (O.R.F.S)
	10	897338	1	SLEEVE		24	6V9168	2	BULKHEAD NUT
M	11	8T4136	1	BOLT		25	6V8627	2	ELBOW
M	12	8T4222	1	WASHER		26	6V8994	2	BULKHEAD ADAPTOR
	13	3B8489	4	GREASE NIPPLE		27	838678	2	HOSE AS.
	14	6R7940	2	PIN		28	897614	1	PIPE CLAMP (16mm DIA)
M	15	6R7959	1	SHIM. 1mm Thick		29	6V8934	2	REDUCER
M	16	6R7960	1	SHIM. 2mm Thick		30	6V8397	4	O. RING

M - METRIC PART
NSS - NOT SERVICED

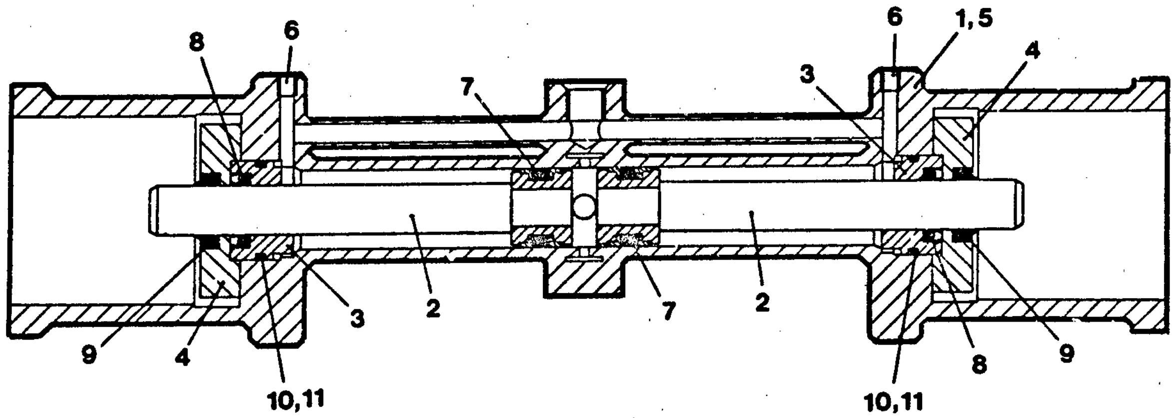
Y - SEPARATE ILLUSTRATION
F - NOT SHOWN

P6R7728 Y
REV 004

6R7728 AUXILIARY HYDRAULIC QUICK HITCH GROUP

844105 - PAGE 226 , 6R7833 - PAGE 282 .

BOOM AND FORKS (AN ATTACHMENT)

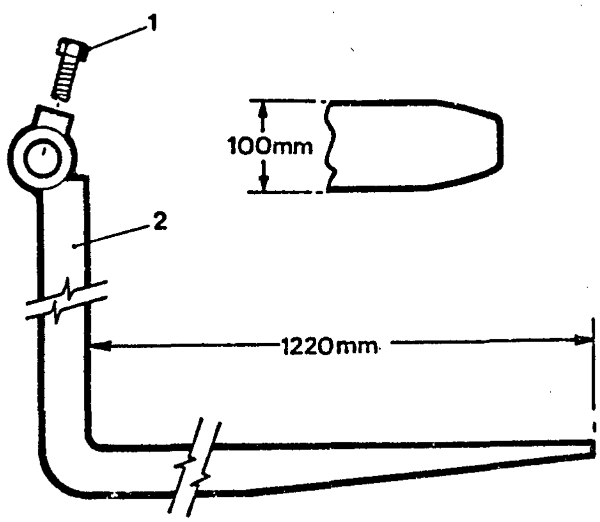


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	5I0589	1	CYLINDER AS
	2	5I0590	2	PISTON ROD AS
	3	5I0592	2	GLAND
	4	5I0593	2	WIPER HOUSING
	5	5I0599	2	ROLL PIN
	6	5I0600	2	PLUG
		6R7784	1	SEAL KIT
	7	5I0594	2	SEAL
	8	5I0595	2	SEAL
	9	5I0596	2	SEAL
	10	5I0597	2	O RING
	11	5I0598	2	BACK-UP RING

P844105 Y
REV001

844105 QUICK HITCH RAM GP
Part of 6R7728 Aux, Hyd. Quick Hitch GP

BOOM AND FORKS (AN ATTACHMENT)

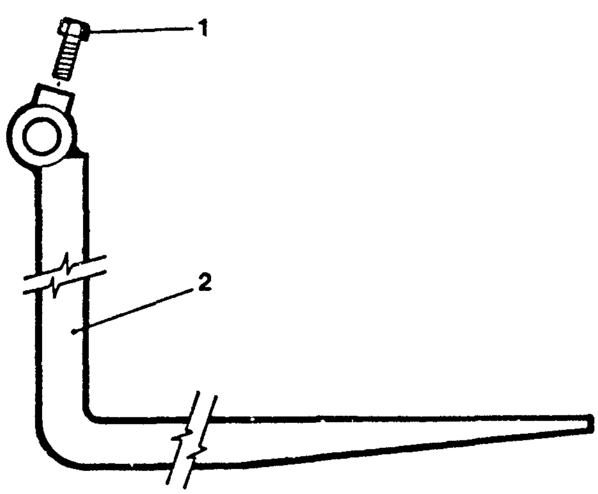


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2L1701	2	BOLT
	2	6R9046	2	PALLET FORK

P6R9046
REV 000

838824 FORK GROUP (4 TONNE)

BOOM AND FORKS (AN ATTACHMENT)

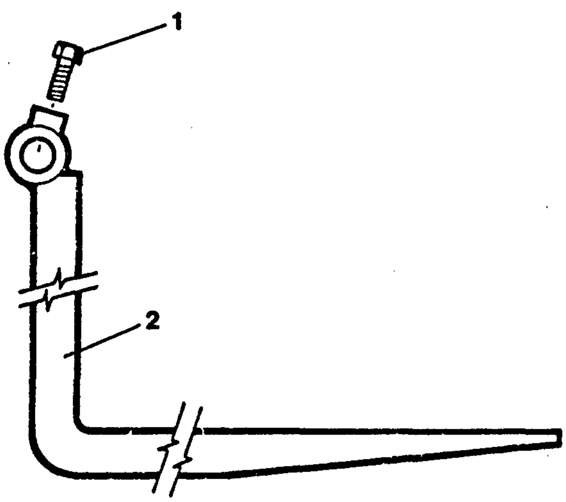


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2L1701	4	BOLT
	2	844054	4	CUBING FORK

P6R7727
REV 000

6R7727 CUBING FORK GROUP (FRAMERS CARRIAGE)

BOOM AND FORKS



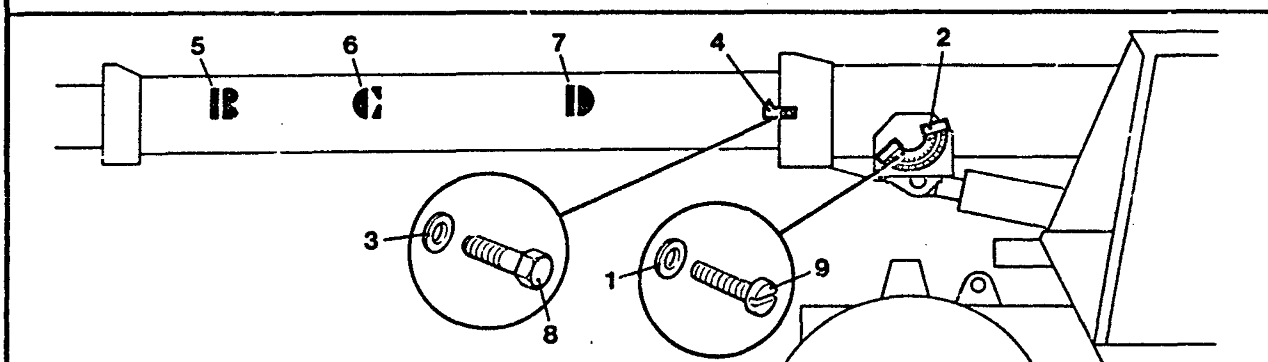
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2L1701	4	BOLT
	2	844054	4	CUBING FORK

P836825

REV000

838825 CUBING FORKS GROUP

BOOM AND FORKS



NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	4B4274	2	WASHER
	2	6R9356	1	BOOM ANGLE INDICATOR
M	3	6V7699	2	WASHER
	4	816174	1	BOOM ANGLE PLATE
	5	838479	1	FILM - LOAD RADIUS "B"
	6	838480	1	FILM - LOAD RADIUS "C"
	7	838481	1	FILM - LOAD RADIUS "D"
M	8	8T0288	2	BOLT
M	9	8T0337	2	SCREW

M - METRIC PART

P838803 Y

REV 000

838803 RADIUS/ANGLE INDICATOR GROUP

MEMORANDUM

MEMORANDUM

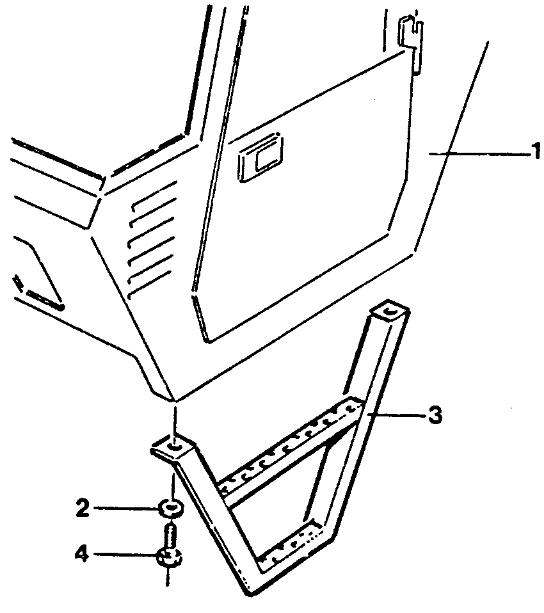
MEMORANDUM

MEMORANDUM

MEMORANDUM

MEMORANDUM

CAB



NOTE	REF NO	PART NUMBER	QTY	PART NAME
NSSY	1	6R9019	1	CAB GROUP BASIC
M	2	5P8247	2	WASHER
	3	838714	1	STEP
M	4	8T0375	2	BOLT
NSSY	F	838454	1	THROTTLE GROUP
NSSY	F	838456	1	PARKING BRAKE GROUP
NSSY	F	6R7913	1	ELECTRICAL GROUP CAB

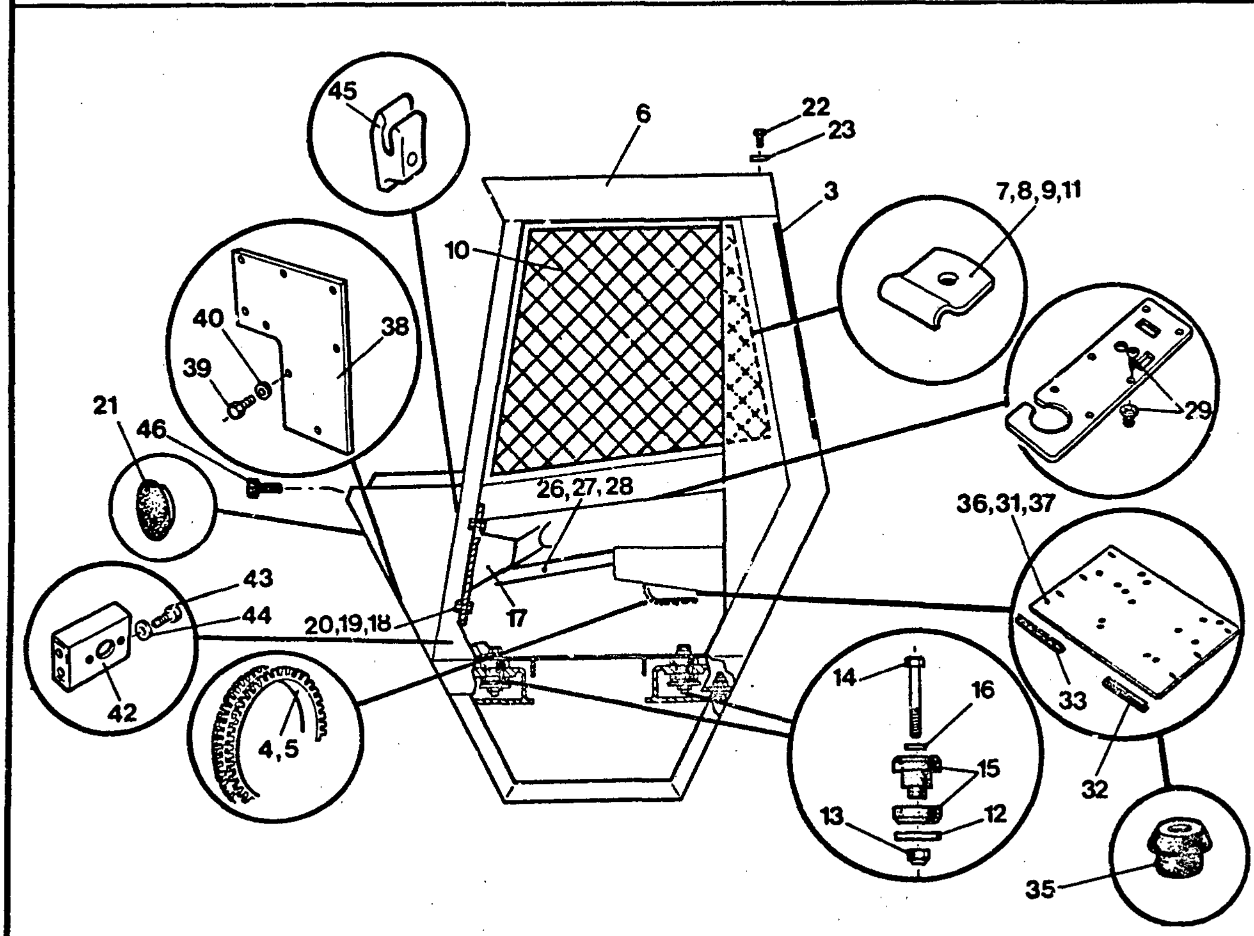
M - METRIC PART
Y - SEPARATE ILLUSTRATION
NSS - NOT SERVICED
F - NOT SHOWN

P6R7740 Y
REV 001

6R7740 OPEN CAB GROUP

6R9019 - PAGE 234 ,838454 - PAGE 75 ,838456 - PAGE 138 ,6R7913 - PAGE 259.

CAB



NOTE	REF NO	PART NUMBER	QTY	PART NAME
F	-	510509	1	PLUG (ANTENNA HOLE)
D	3	815720	2.6	SEAL SELF GRIP
D	4	838639	.42	SAFE EDGING
B	5	838847	-	CONTACT ADHESIVE
	6	844305	1	OPERATORS CAB FABRICATION
M	7	6V7699	10	WASHER
M	8	6V9188	10	NYLOC NUT
	9	815697	10	TUBE CLIP
	10	838950	1	MESH SIDE WINDOW
M	11	8T0288	10	BOLT
	12	6R7737	4	SPACER
M	13	7X0581	4	NUT
M	14	8T0669	4	BOLT
	15	9R0394	4	MOUNTING ASS'Y
M	16	9R3403	4	SPECIAL WASHER
Y	17	8Q2496	1	STEERING CONSOLE GROUP
M	18	6V7744	6	SELF LOCKING NUT
M	19	8T4121	6	WASHER
M	20	8T4195	6	BOLT
	21	9D3767	1	BUTTON PLUG
M	22	5P2228	2	BOLT
M	23	8T4223	2	WASHER
F	–	2U4445	4	GROMMET - HEATER PIPE HOLES
F	–	4H3001	2	PLUG - WIPER MOTOR HOLES

NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	26	6V7743	2	NYLOC NUT
	27	8Q2743	1	HARNESS COVER
M	28	8T4205	2	WASHER
	29	6R7791	6	SCRIVVETT
NSS	YF	6R9357	1	SEAT CLOSING PLATE GROUP
	31	8Q2404	1	CLOSING PLATE
D	32	898054	.14	EDGING STRIP
D	33	898054	.15	EDGING STRIP
F	–	2U4729	1	GROMMET - BLIND
	35	8C5607	8	MOUNT
M	36	7X2537	4	BOLT
M	37	8T4224	4	WASHER
	38	6R7627	1	PLATE - COVER FRONT PANEL
M	39	7X2536	7	BOLT
M	40	8T4224	7	WASHER
NSS	YF	8Q2731	1	DOCUMENT POUCH - GROUP
	42	844223	1	BRACKET - DIFF LOCK SWITCH
M	43	8T4138	2	BOLT
M	44	8T4205	2	WASHER
	45	816087	1	PLASTIC CLIP
M	46	8Q2694	7	PLASTIC SCREW

B - USE AS REQUIRED
D - ORDER BY THE METER
F - NOT SHOWN

M - METRIC PART
Y - SEPARATE ILLUSTRATION
NSS - NOT SERVICED

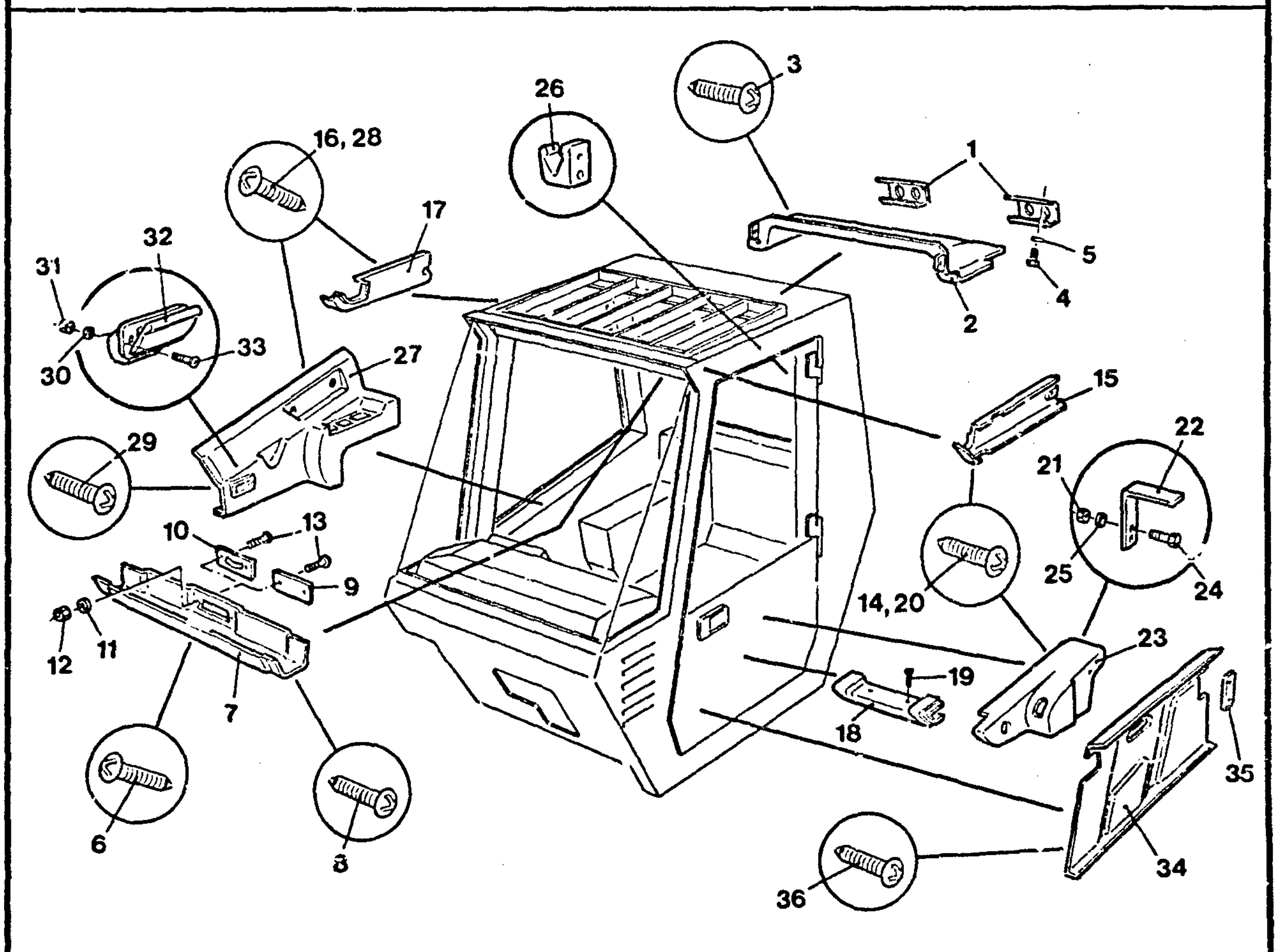
P6R9019 Y
REV 015

6R9019 CAB GROUP BASIC

Part of 6R7732 Open Cab Group

8Q2496 - PAGE 141, 8Q2731 - PAGE 239, 6R9357 - PAGE 240.

CAB (AN ATTACHMENT)



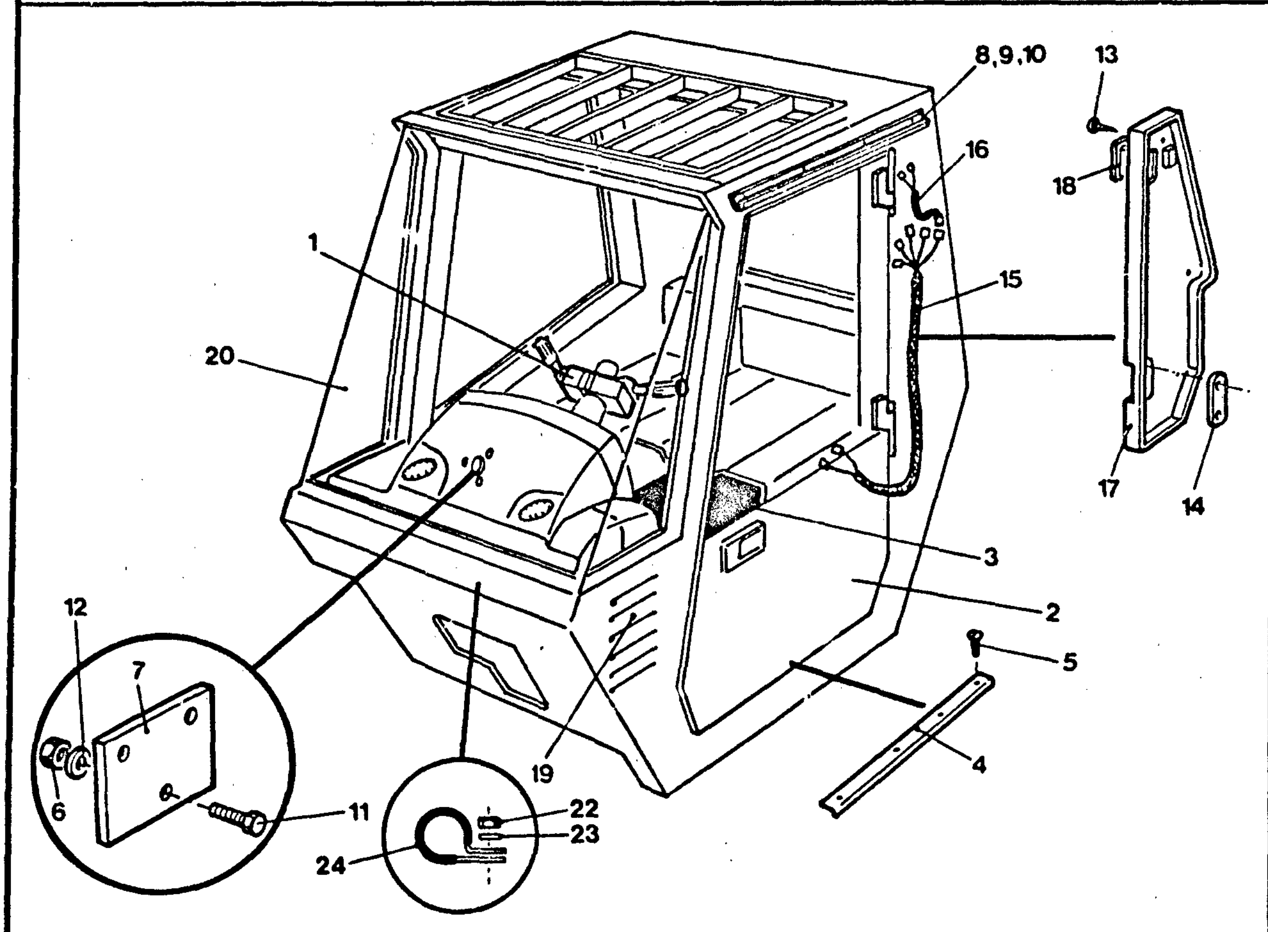
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7631	2	HEADLINING SUPPORT BRACKET		22	844087	1	TRIM SUPPORT BRACKET
	2	844062	1	HEADLINING - REAR		23	844089	1	SEAT & HANDBRAKE COVER
	3	897959	2	SCREW	M	24	8T4138	2	BOLT
M	4	8T4171	4	BOLT	M	25	8T4205	2	WASHER
M	5	8T4205	4	WASHER		26	6V8928	1	COAT HOOK
	6	6R7921	2	SCREW		27	6R7860	1	CONTROL PANEL TRIM
	7	844063	1	HEADLINING - FRONT		28	6R7921	2	SCREW
	8	897959	2	SCREW		29	897959	1	SCREW
	9	6R7942	1	PLATE COVER - SPIRIT LEVEL (RIGID MACHINES)	M	30	6V7699	2	WASHER
		OR			M	31	6V9188	2	NUT
						32	8C0618	1	ASH TRAY
	10	844254	1	LEVEL INDICATOR COVER (SELF LEVELLING MACHINES)	M	33	985621	2	SCREW
						34	6R7944	1	DOOR PANEL COMPLETE
M	11	6V7699	2	WASHER		35	6R9215	1	PLATE - CHECK STRAP SEATING
M	12	6V9188	2	NUT		36	897959	5	SCREW
M	13	985621	2	SCREW	YNSS	F	6R7732	1	ALL WEATHER CAB
	14	6R7921	2	SCREW					
	15	844250	1	ROOF LINING L.H.					
	16	6R7921	2	SCREW					
	17	844251	1	ROOF LINING R.H.					
	18	844252	1	SEAT TRIM					
	19	897959	2	SCREW					
	20	6R7921	1	SCREW					
M	21	6V7743	2	NUT					

F - NOT SHOWN　　M - METRIC PART
NSS - NOT SERVICED　　Y - SEPARATE ILLUSTRATION

P6R7733 Y
REV 002

6R7733 DE LUXE ALL WEATHER CAB
6R7732 - PAGE 236.

CAB



NOTE	REF NO	PART NUMBER	QTY	PART NAME
NSSY	1	6R7918	1	STEER COLUMN SWITCH GROUP
NSSY	2	6R9341	1	OPERATORS CAB DOOR GROUP
NSSY	3	8Q2704	1	MAT CAB INTERIOR GROUP
	4	6R7927	1	CORNER MOULD
	5	8T0387	4	SCREW
M	6	5C7261	3	NUT
	7	6R7922	1	COVER PLATE
B	8	815651	-	BOSTIK CLEAR SEALANT
	9	838603	4	RIVET
	10	838739	1	PLATE RAIN GUARD
M	11	8T4189	3	BOLT
M	12	8T4224	3	WASHER
	13	6R7921	4	SCREW
	14	6R9215	1	PLATE
	15	844125	1	HARNESS AS. ROOF
	16	844130	1	HARNESS AS.-CAB LAMP
	17	844256	1	SIDE TRIM PANEL
	18	844277	1	INTERIOR LIGHT
NSSY	19	6R7920	1	CAB HEATER GROUP
NSSY	20	6R7702	1	CAB GLAZING GROUP
M	22	6V7743	2	NYLOC NUT
M	23	8T4205	2	WASHER
	24	985721	2	P. CLIP
NSSY	F	6R9351	1	WASHER GROUP - FRONT SCREEN
NSSY	F	897547	1	WINDSCREEN WIPER GROUP

B-USE AS REQUIRED
M - METRIC PART

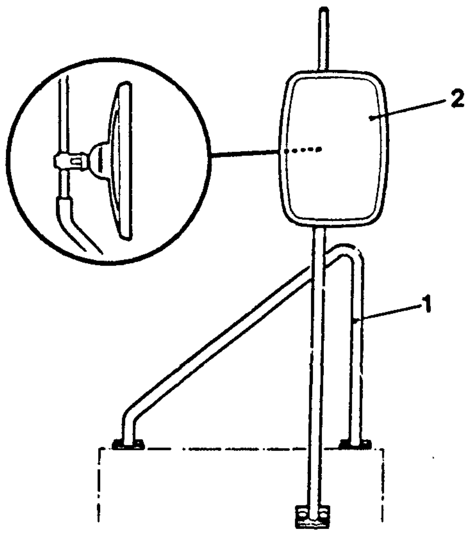
NSS - NOT SERVICED
Y - SEPARATE ILLUSTRATION

P6R7732 Y
REV 007

6R7732 ALL WEATHER CAB

6R7920 - PAGE 246, 6R7702 - PAGE 251, 6R7918 - PAGE 146, 6R9341 - PAGE 243,

CAB

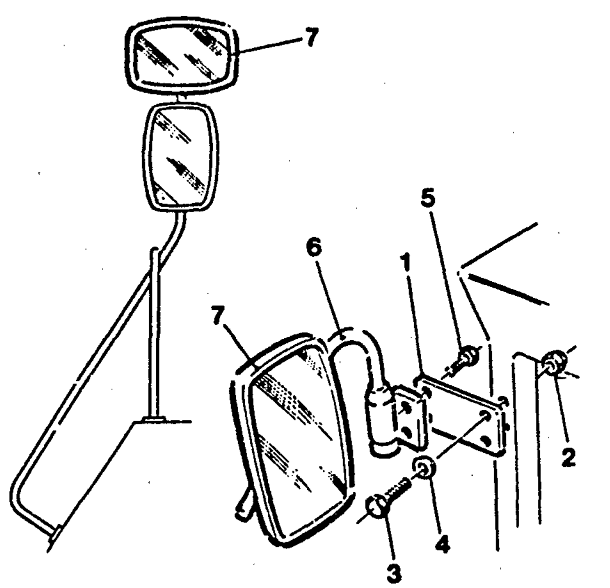


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	8Q2072	1	GRAB HANDLE
	2	7X0800	1	MIRROR

P8Q2077 Y
REV 000

8Q2077 MIRROR GROUP

CAB



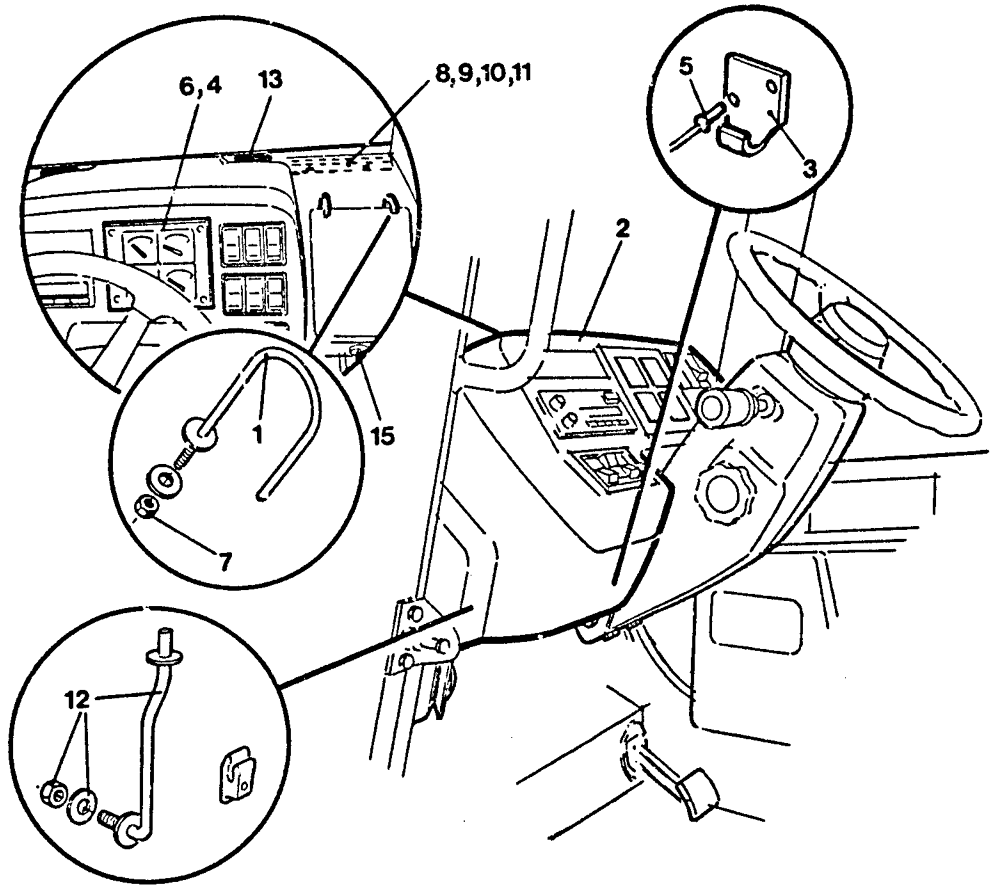
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7906	1	MIRROR SUPPORT PLATE
M	2	6V9189	2	NYLOC NUT
M	3	8T3647	2	BOLT
M	4	8T4224	2	WASHER
M	5	6F7027	2	BOLT.
	6	6R7889	1	MIRROR ARM
	7	844312	2	WING MIRROR

M - METRIC PART

P6R9109 Y
REV 001

6R9109 WING MIRROR GROUP

CAB



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7543	2	RING FLIP CHART		8	6R9274	1	HINGE AS. GROUP - INCLUDING;-
	2	6R8999	1	INSTRUMENT PANEL AS-INCLUDING;-	M	9	6R7639	4	SCREW
	3	6R9236	2	LATCH		10	6R7640	1	HINGE AS.
	4	6R9280	1	INSTRUMENT PANEL	M	11	6V7743	4	NYLOC NUT
	5	838603	8	RIVET		12	6R7573	1	INSTRUMENT PANEL STAY AS.
	6	844276	2	BRACKET- GAUGE SUPPORT		13	1L6366	2	BUTTON PLUG
M	7	6V7743	2	NYLOC NUT	NSSY	F	6R8993	1	ELECTRICAL GROUP DASH
						15	9G7641	1	KEY SWITCH

M - METRIC PART NSS - NOT SERVICED Y - SEPARATE ILLUSTRATION

P6R8998 Y

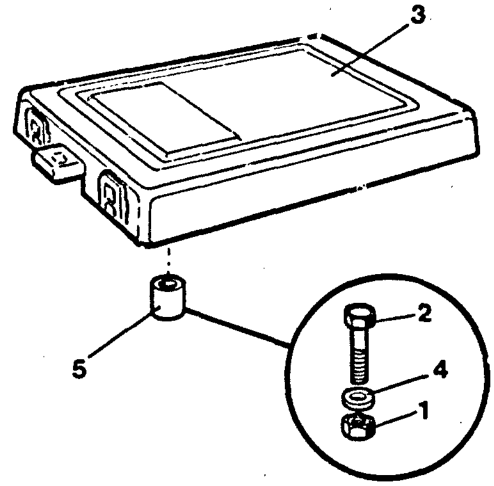
REV004

6R8988 DASHPANEL GROUP

6R8993 - PAGE 257

Part of 6R7913 Electrical Group - Cab

CAB



NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	5C2890	4	NUT
M	2	5C9553	4	BOLT
	3	5P9796	1	DOCUMENT POUCH
M	4	8T4205	4	WASHER
	5	985194	2	SPACER

M - METRIC PART

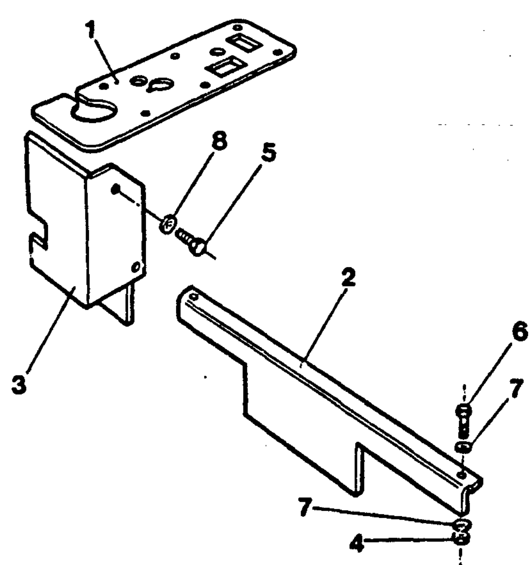
P8Q2731

REV 000

8Q2731 DOCUMENT POUCH GROUP

PART OF 6R9019 BASIC CAB GROUP

CAB



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9343	1	PLATE - CONTROL PANEL
	2	6R9345	1	PLATE - SEAT CLOSING (FRONT)
	3	6R9355	1	CONTROL PANEL A.S.
M	4	6V7743	2	NYLOC NUT
M	5	7X2536	2	BOLT
M	6	8T4138	2	BOLT
M	7	8T4205	4	WASHER
M	8	8T4224	2	WASHER

M - METRIC PART

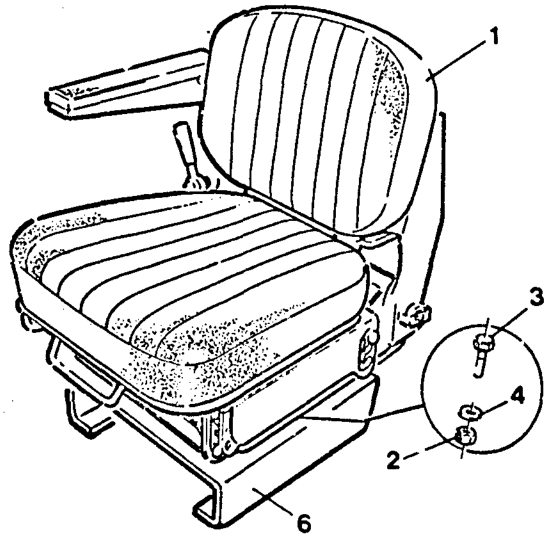
P6R9357 Y

REV 000

6R9357 SEAT CLOSING PLATE GROUP

Part of 6R9019 Basic Cab Group

CAB



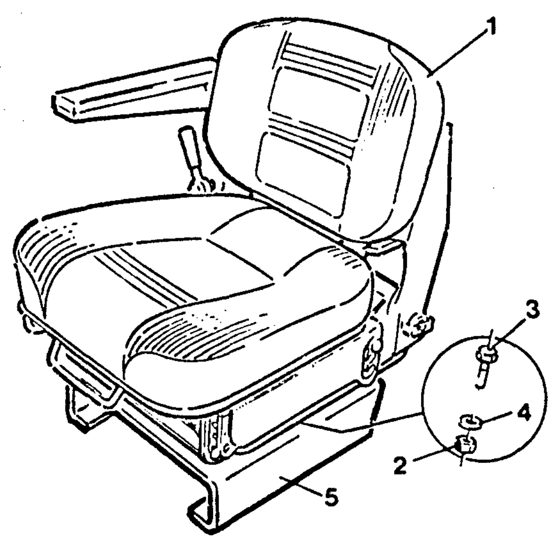
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9228	1	SEAT STATIC VINYL
M	2	6V9189	8	NYLOC NUT
M	3	8T4189	8	BOLT
M	4	8T4224	8	WASHER
Y	F	8Y4030	1	SEAT BELT GROUP
M	F	5V5262	1	BOLT - SEAT BELT ATTACHING
M	F	8T4223	1	WASHER - SEAT BELT ATTACHING
	6	6R7859	1	SEAT SUPPORT BRACKET

F - NOT SHOWN
M - METRIC PART
Y - SEPARATE ILLUSTRATION

P6R7743 Y
REV 002

6R7743 SEAT GROUP (VINYL) STATIC

CAB (AN ATTACHMENT)



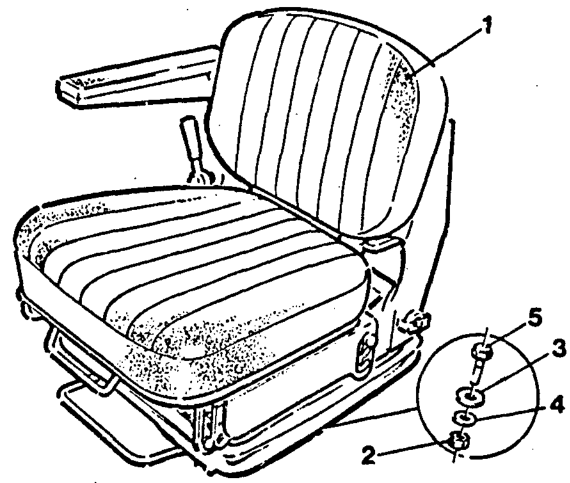
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9229	1	SEAT STATIC CLOTH
M	2	6V9185	8	NYLOC NUT
M	3	8T4189	8	BOLT
M	4	8T4224	8	WASHER
	5	6R7859	1	SEAT SUPPORT BRACKET

M - METRIC PART

P6R7473 Y
REV 001

6R7473 SEAT GROUP (CLOTH) STATIC

CAB (AN ATTACHMENT)



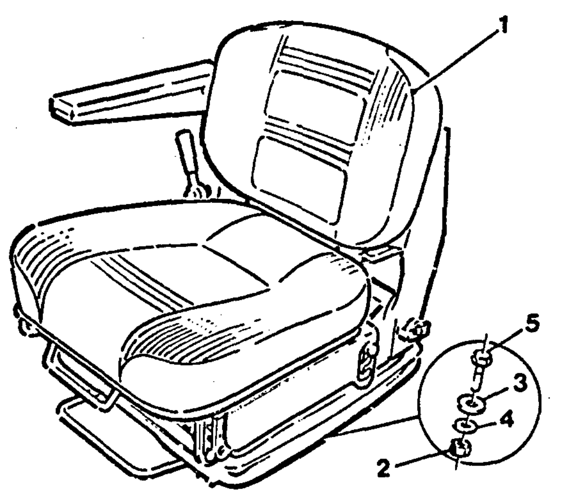
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9230	1	SEAT SUSPENSION VINYL
M	2	6V9189	4	NYLOC NUT
M	3	7S6369	4	WASHER
M	4	8T4224	4	WASHER
M	5	8T4908	4	BOLT
Y	F	8Y4030	1	SEAT BELT
M	F	5V5262	1	BOLT - SEAT BELT ATTACHING
M	F	8T4223	1	WASHER - SEAT BELT ATTACHING

Y - SEPARATE ILLUSTRATION
M - METRIC PART
F - NOT SHOWN

REV 001 Y
P6R7700

6R7700 SEAT GROUP (VINYL) SUSPENSION

CAB (AN ATTACHMENT)



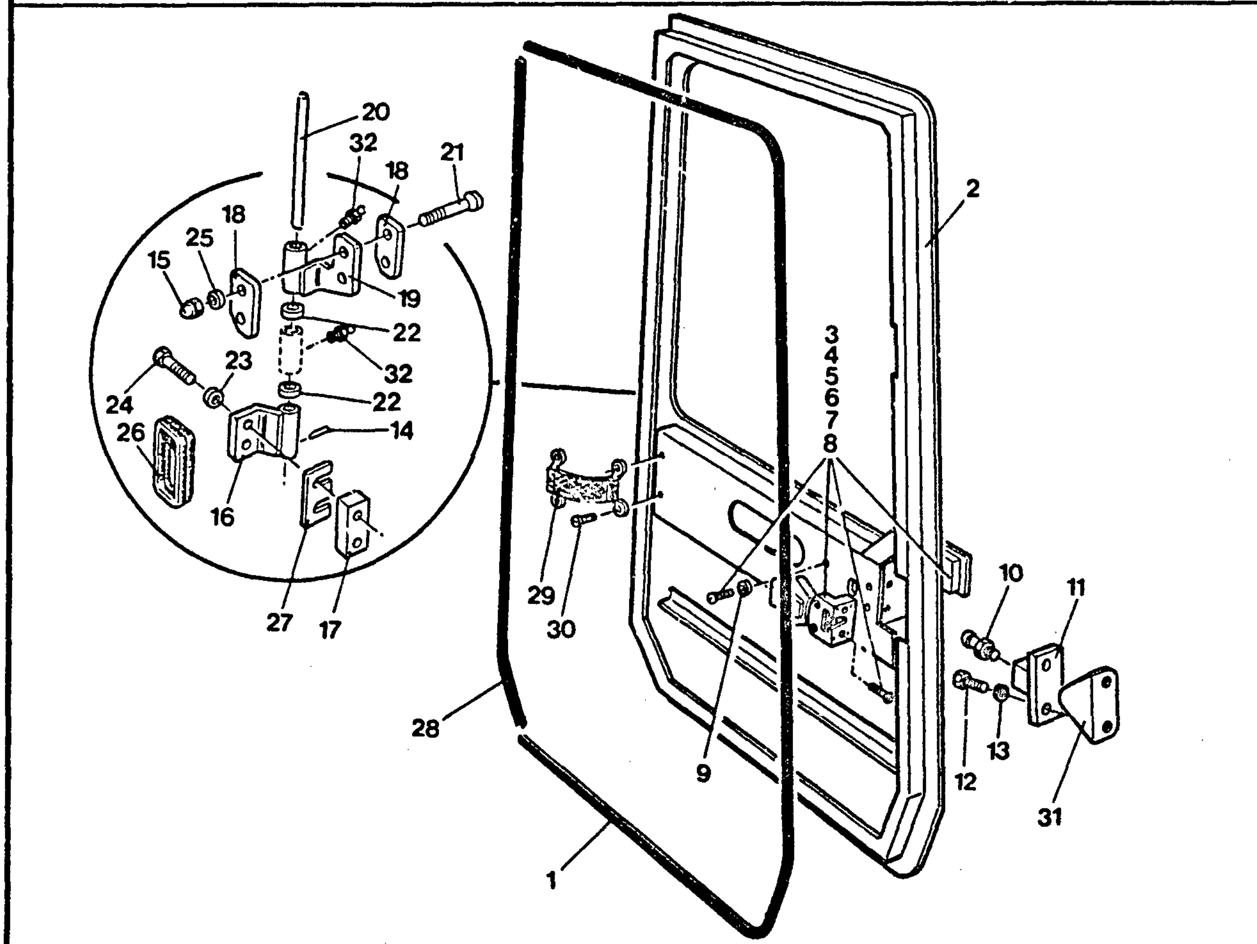
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9231	1	SEAT SUSPENSION CLOTH
M	2	6V9189	4	NYLOC NUT
M	3	7S6369	4	WASHER THICK
M	4	8T4224	4	WASHER
M	5	8T4908	4	BOLT

M - METRIC PART

REV 001 Y
P844094

844094 SEAT GROUP (CLOTH) SUSPENSION

CAB



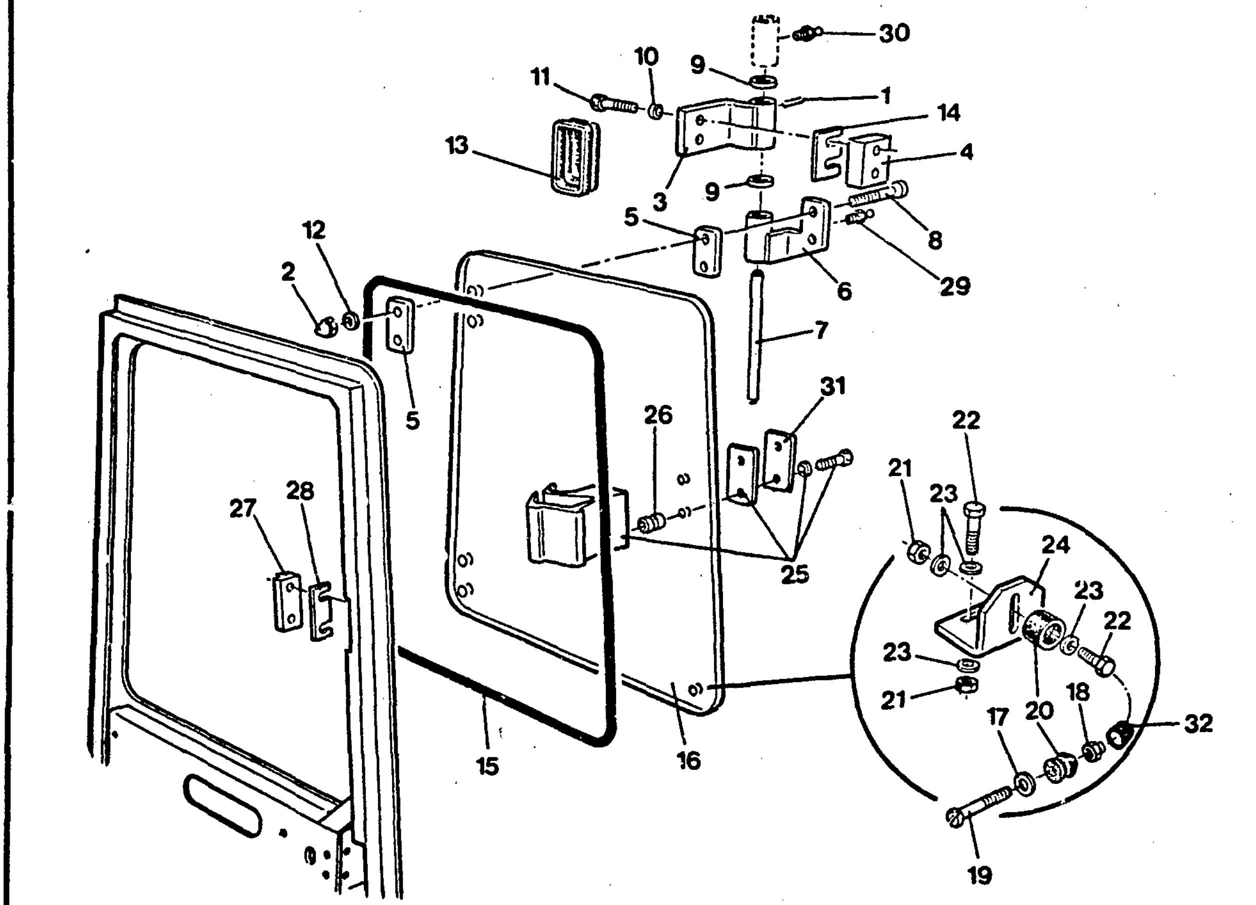
NOTE	REF NO	PART NUMBER	QTY	PART NAME
D	1	838735	3M	RUBBER SECTION - DOOR
	2	6R9340	1	CAB DOOR AS
	3	815662	1	PADDLE HANDLE, INCLUDING:
	4	NSS	1	INTERIOR HANDLE
	5	NSS	1	EXTERIOR HANDLE
	6	NSS	1	PIN
M	7	NSS	2	SCREW (M5 x 40)
M	8	NSS	1	SCREW (M5 x 30)
	9	897960	1	WASHER
	10	815641	1	PIN
	11	838736	1	PIN STRIKER
M	12	8T4200	2	BOLT
M	13	8T4224	2	WASHER
	14	2L5894	2	PIN
M	15	815526	2	NUT
	16	6R8962	1	HINGE - CAB
	17	815613	1	BLOCK
	18	6R9359	2	SPACER PAD
	19	838733	1	HINGE - GLASS
	20	838740	1	PIN
M	21	816105	2	BOLT
	22	897627	2	THRUST WASHER
M	23	8T4121	4	WASHER
M	24	8T4195	2	BOLT
M	25	8T4224	2	WASHER
	26	9R1759	1	GROMMET
B	27	9R2037	-	SHIM
D	28	815643	2M	RUBBER SECTION - CAB
	29	985418	1	CHECK STRAP
M	30	985621	4	SCREW
	31	6R7607	1	STRIKER SHIELD
	32	6V1506	2	GREASE NIPPLE

B - USE AS REQUIRED M - METRIC PART
D - ORDER BY THE METER NSS - NOT SERVICED

P6R9341 Y
REV003

6R9341 OPERATORS CAB DOOR GROUP (1 OF 2)
Part of 6R7732 All Weather Cab Group

CAB



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2L5894	2	PIN
M	2	815526	2	NUT
	3	6R8962	1	HINGE - CAB
	4	815613	1	BLOCK
	5	816077	2	SPACER PAD
	6	838733	1	HINGE - GLASS
	7	838740	1	PIN
M	8	816105	2	BOLT
	9	897627	2	THRUST WASHER
M	10	8T4121	2	WASHER
M	11	8T4195	2	BOLT
M	12	8T4224	2	WASHER
	13	9R1759	1	GROMMET
B	14	9R2037	-	SHIM
D	15	815642	3M	RUBBER SECTION - WINDOW
	16	838732	1	GLASS - DOOR
M	17	6V7699	1	WASHER
M	18	815848	1	NUT

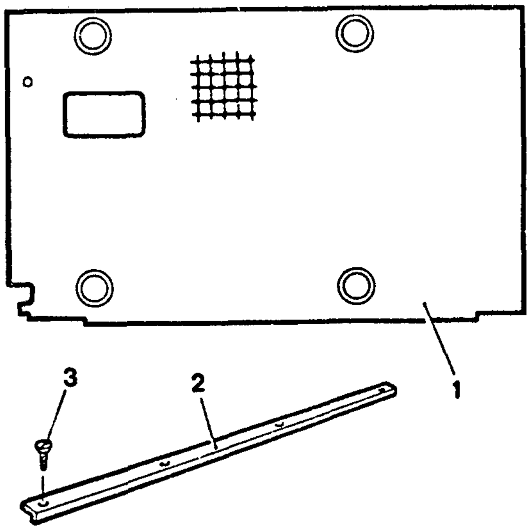
NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	19	8T6693	1	SCREW
	20	985885	1	RUBBER DOOR HOLDER
M	21	6V7743	3	NUT
M	22	8T4138	3	BOLT
M	23	8T4205	6	WASHER
	24	985884	1	BRACKET
	25	8T4160	1	HANDLE AS
	26	8T3849	1	INSERT
	27	6V6885	1	STRIKER
B	28	9R1918	-	SHIM
	29	6V1506	1	GREASE NIPPLE
	30	6V1506	1	GREASE NIPPLE
	31	8Q2698	1	PLATE
	32	985935	1	NUT PROTECTION CAP

B - USE AS REQUIRED D - ORDER BY THE METER
M - METRIC PART

P6R9341 Y
REV003

6R9341 OPERATORS CAB DOOR GROUP (2 OF 2)
Part of 6R7732 All Weather Cab Group

CAB (AN ATTACHMENT)



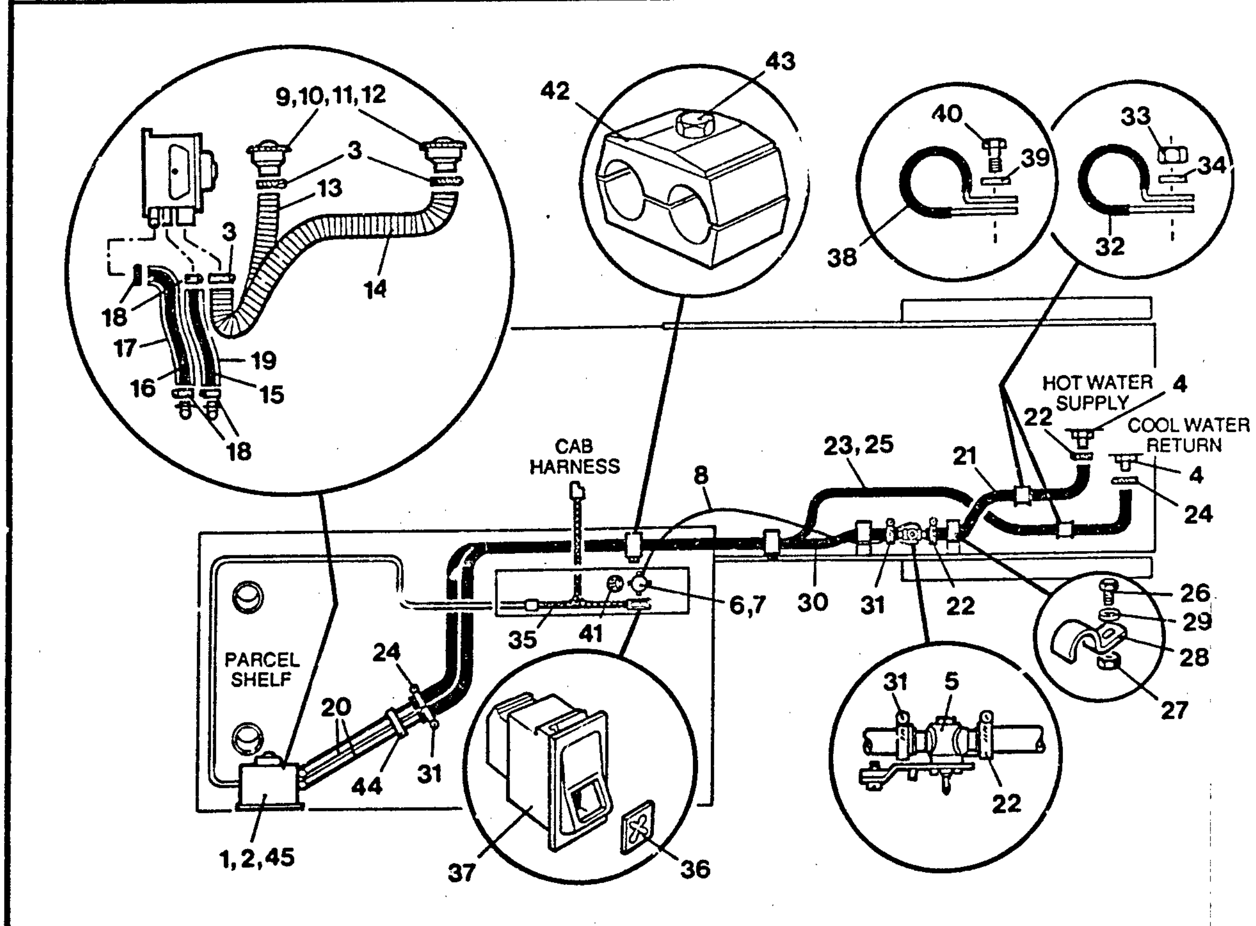
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	8Q2686	1	RUBBER MAT (BROWN)
	2	6R7927	1	CORNER MOULD
M	3	8T0387	4	SCREW

M - METRIC PART

P8Q2704 Y
REV 000

8Q2704 MAT GROUP - CAB INTERIOR
Part of 6R7732 All Weather Cab Group

CAB (AN ATTACHMENT)



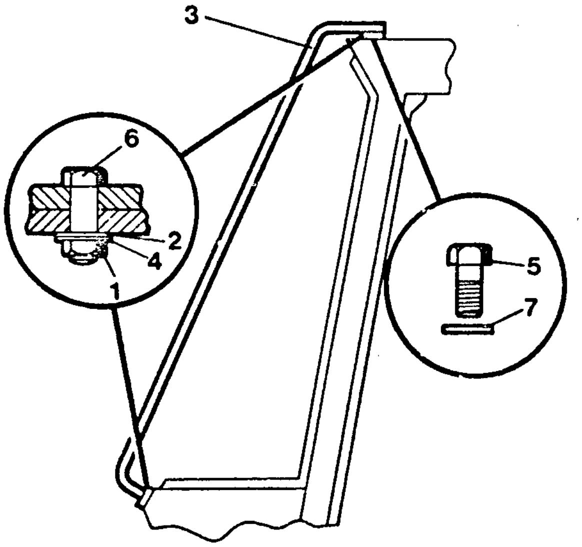
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	5C9553	4	BOLT		23	6R9064	1	HEATER HOSE
		6R9347	1	HEATER KIT,INCLUDING:		24	8T0154	2	HOSE CLAMP
	2	6R7790	1	HEATER UNIT		25	985708	5	CABLE TIE
	3	815529	4	CLIP	M	26	6V7357	2	BOLT
	4	815952	2	CONNECTOR	M	27	6V7743	2	NYLOC NUT
	5	838595	1	WATER VALVE		28	838643	2	CLAMP
	6	897755	1	HEATER CONTROL, INCLUDING;-	M	29	8T4205	2	WASHER
	7	8Q2092	1	KNOB		30	6R7914	1	HEATER HOSE
	8	6R7936	1	CABLE		31	8T0154	2	CLAMP
M	9	5C8312	8	NUT		32	3U2755	2	P. CLIP
	10	6U5685	2	AIR NOZZLE	M	33	6V7743	2	NYLOC NUT
M	11	6V9499	8	WASHER	M	34	8T4205	2	WASHER
M	12	8T0309	8	SCREW		35	6R7582	1	HARNESS AS - HEATER SW.
	13	6R7904	1	DEMISTER HOSE		36	6U5789	1	PLATE--HEATER
	14	6R7905	1	DEMISTER HOSE		37	844200	1	HEATER SWITCH ILLUMINATION
	15	6R7912	1	HEATER HOSE		38	3U2755	1	P. CLIP
	16	6R9049	1	HEATER HOSE	M	39	8T4121	1	WASHER
	17	6R9058	2	DUCTING		40	8T8906	1	BOLT
	18	8T0154	4	HOSE CLAMP		41	985234	1	DECAL - HEATER CONTROL
	19	985271	1	DUCTING		42	815759	2	CLAMP
	20	6R7903	2	PIPE	M	43	8T3647	2	BOLT
	21	6R9063	1	HEATER HOSE		44	897614	1	CLAMP
	22	8T0154	2	HOSE CLAMP		45	8T4205	4	WASHER

M - METRIC PART

P6R7920 Y
REV002

6R7920 CAB HEATER GROUP
Part of 6R7732 All Weather Cab Group

CAB (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME
M	1	6V7744	7	SELF LOCKING NUT
	2	838492	7	WASHER - SEALING
	3	838932	1	GRILL AS.
M	4	8T4121	7	WASHER
M	5	8T4192	1	BOLT
M	6	8T4195	7	BOLT
M	7	8T4223	1	WASHER

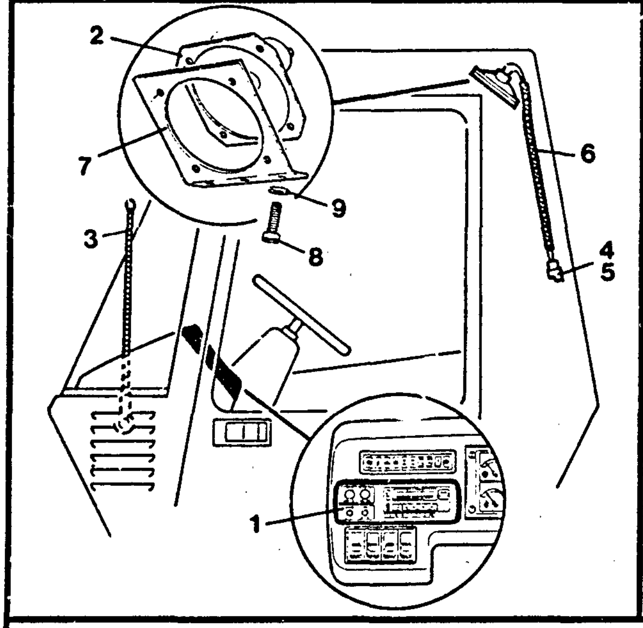
M - METRIC PART

P844304 Y

REV 001

844304 WINDSCREEN GRILL GROUP

CAB (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7878	1	RADIO-CASSETTE
	2	6R9110	1	SPEAKER KIT
	3	6R9118	1	ANTENNA
	4	7N7779	3	SOCKET
	5	7N7780	3	PIN
	6	844138	1	HARNESS AS - SPEAKERS
	7	844253	2	SPEAKER SUPPORT - BRACKET
M	8	8T4171	6	BOLT
M	9	8T4205	6	WASHER

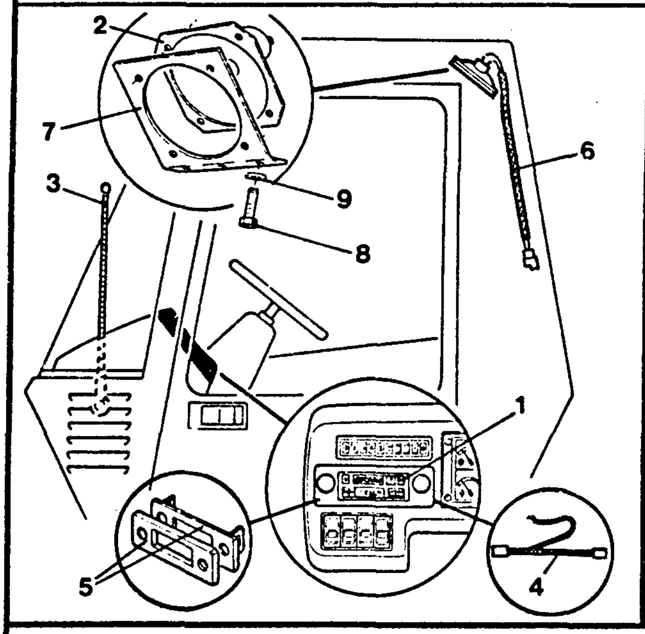
M - METRIC PART

P6R7730 Y

REV000

6R7730 RADIO/CASSETTE GROUP (C.O.S.A.)

CAB (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9X3509	1	RADIO-CASSETTE
	2	6R9110	1	SPEAKER KIT
	3	6R9118	1	ANTENNA
	4	8Q2784	1	HARNESS - RADIO
	5	8Q2783	1	ADAPTOR KIT
	6	844138	1	HARNESS AS - SPEAKERS
	7	844253	2	SPEAKER SUPPORT - BRACKET
M	8	8T4171	6	BOLT
M	9	8T4205	6	WASHER

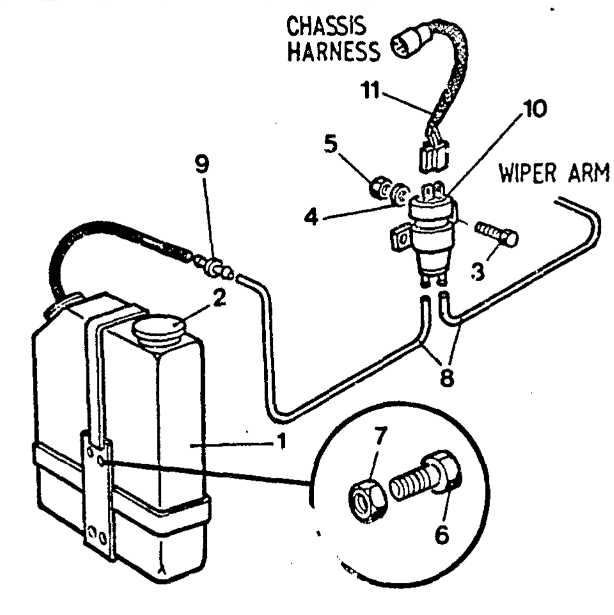
M - METRIC PART

P6R7731 Y

REV000

6R7731 RADIO/CASSETTE GROUP (U.S.A)

CAB



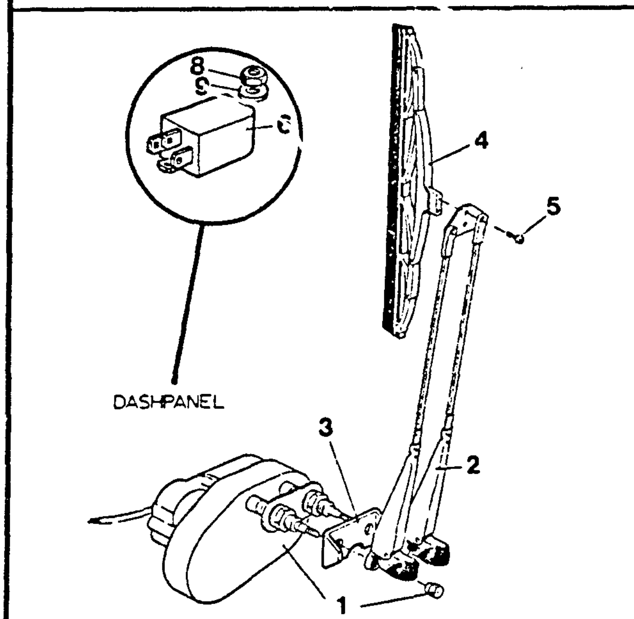
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	2U4498	1	BOTTLE KIT
	2	6V2679	1	LABEL
M	3	6V4298	2	BOLT
M	4	6V7699	2	WASHER
	5	6V9188	2	NYLOC NUT
M	6	8T0285	4	BOLT
M	7	8T7961	1	NYLOC NUT
D	8	816177	7.0	TUBE
	9	2U4709	1	NONE - RETURN VALVE
	10	6R7926	1	PUMP
	11	8Q2095	1	HARNESS AS.

D - ORDER BY THE METER
M - METRIC PART

P6R9351 Y
REV 001

6R9351 WASHER GROUP. (FRONT SCREEN)
Part of 6R7732 All Weather Cab Group

CAB (AN ATTACHMENT)



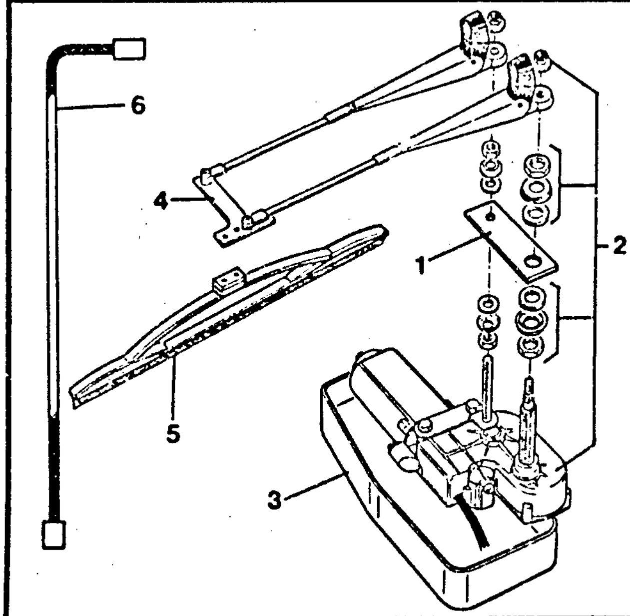
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	897550	1	MOTOR
	2	897549	1	ARM ASSEMBLY
	3	897546	1	SPACER
	4	897548	1	BLADE ASSEMBLY
	5	2U2751	2	SCREW
	6	815803	1	INTERMITTENT WIPE UNIT
C		—	—	—
MC	8	5C2890	1	NUT
MC	9	8T4205	1	WASHER

M - METRIC PART
C - INDICATES CHANGE

P897547
REV 002

897547 WINDSCREEN WIPER GROUP (ALL WEATHER CAB)
Part of 6R7732 All Weather Cab Group

CAB (AN ATTACHMENT)



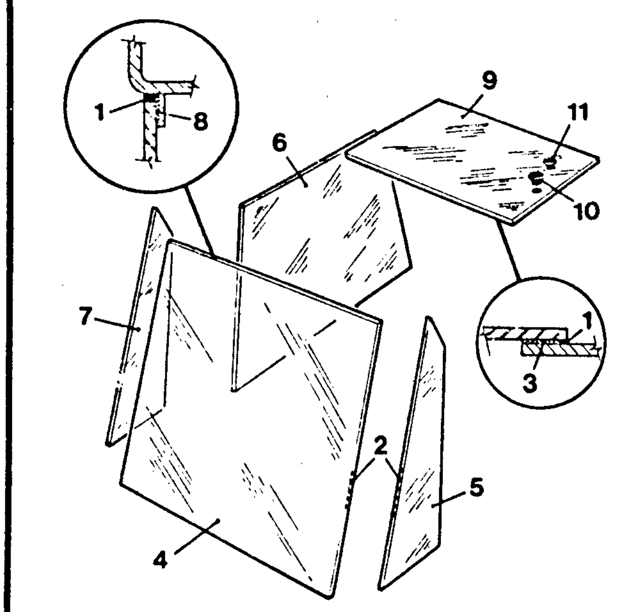
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	838698	1	PLATE
	2	844095	1	WIPER UNIT
	3	844096	1	COVER
	4	844097	1	ARM
	5	844098	1	BLADE
	6	844129	1	HARNESS - WIPER

P6R7646 Y

REV 000

6R7646 ROOF WIPER GROUP

CAB (AN ATTACHMENT)



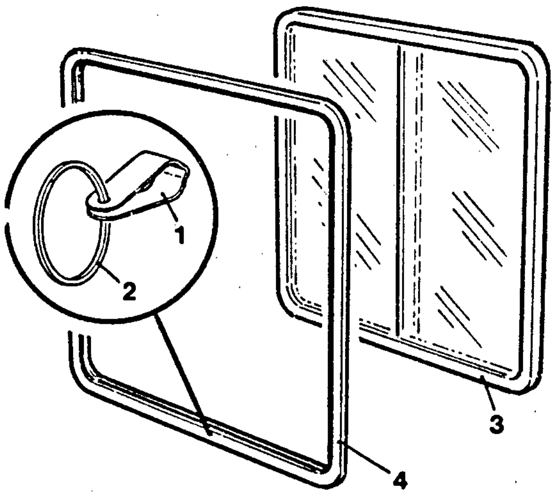
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815650	B	SEALANT
	2	815651	B	SEALANT - CLEAR
	3	815658	B	SEALANT TAPE
	4	897463	1	FRONT SCREEN
	5	897464	1	SIDE SCREEN L.H.
	6	897465	1	SIDE WINDOW
	7	897744	1	SIDE SCREEN R.H.
	8	815658	B	SEALANT TAPE
	9	838769	1	GLASS PANEL -ROOF
	10	844153	1	PROTECTION PLUG
	11	844154	1	PROTECTION PLUG
NSSY	F	6R9210	1	REAR WINDOW GROUP
	F	975580	1	DECAL - SECONDARY EXIT
	F	898052	B	GLASS PRIMER

B - USE AS REQUIRED NSS - NOT SERVICED
F - NOT SHOWN Y - SEPARATE ILLUSTRATION

P6R7702
REV004

6R7702 CAB GLAZING GROUP
Part of 6R7732 Cab Glazing Group

CAB (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	5C8310	1	BRACKET - RING PULL
	2	5C8311	1	RING PULL
	3	6R7712	1	WINDOW REAR SLIDING
	4	6R7787	B	WINDOW SEAL
	F	815651	B	CLEAR SEALANT

B - USE AS REQUIRED
F - NOT SHOWN

P6R9210 Y
REV000

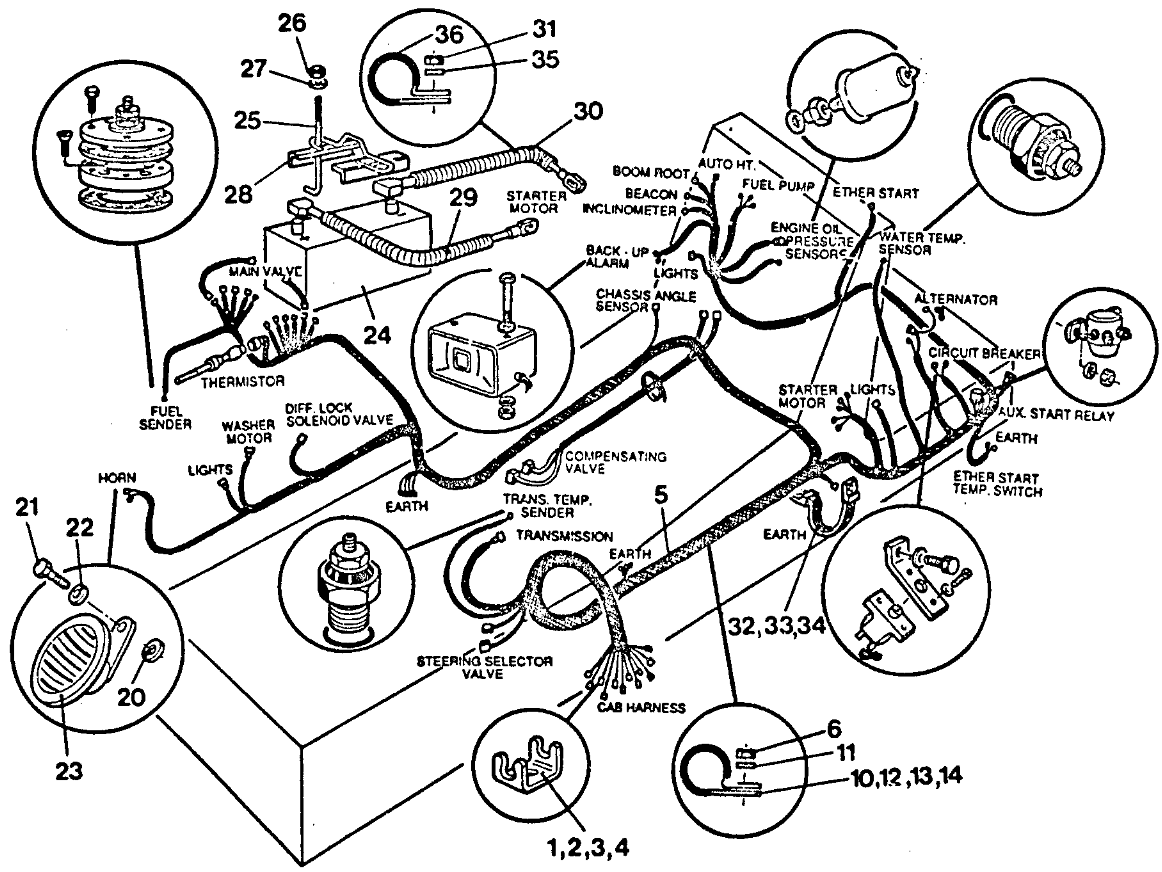
6R9210 REAR WINDOW GROUP
Part of 6R7702 Cab Glazing GP.

MEMORANDUM

MEMORANDUM

MEMORANDUM

ELECTRICAL EQUIPMENT



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3T3045	7	METAL CLIP
	2	3T3046	6	METAL CLIP (10 PIN)
	3	3T3047	12	METAL CLIP
	4	3T3048	10	METAL CLIP
	5	6R7795	1	HARNESS AS. - CHASSIS
M	6	6V7743	23	NYLOC NUT
	F	7N8204	1	SURE SEAL SOCKET - 4 PIN
	F	7N8205	1	SURESEAL PLUG - 4PIN
	F	7N9737	4	SURESEAL PLUG - 2 PIN
	10	815917	5	P. CLIP 32mm DIA
M	11	8T4205	23	WASHER
	12	985714	7	P. CLIP 20mm DIA
	13	985720	6	P. CLIP 27mm DIA
	14	985721	2	P. CLIP 12mm DIA
F	-	9G3671	2	SURESEAL PLUG - 6 PIN
F	-	9G3672	2	SURESEAL PLUG - 5 PIN
F	-	9G3677	1	SURESEAL PLUG - 6 PIN
F	-	9G3678	1	SURESEAL RECEPTACLE - 5 WAY
F	-	9G3695	49	SURESEAL SEALING PLUG

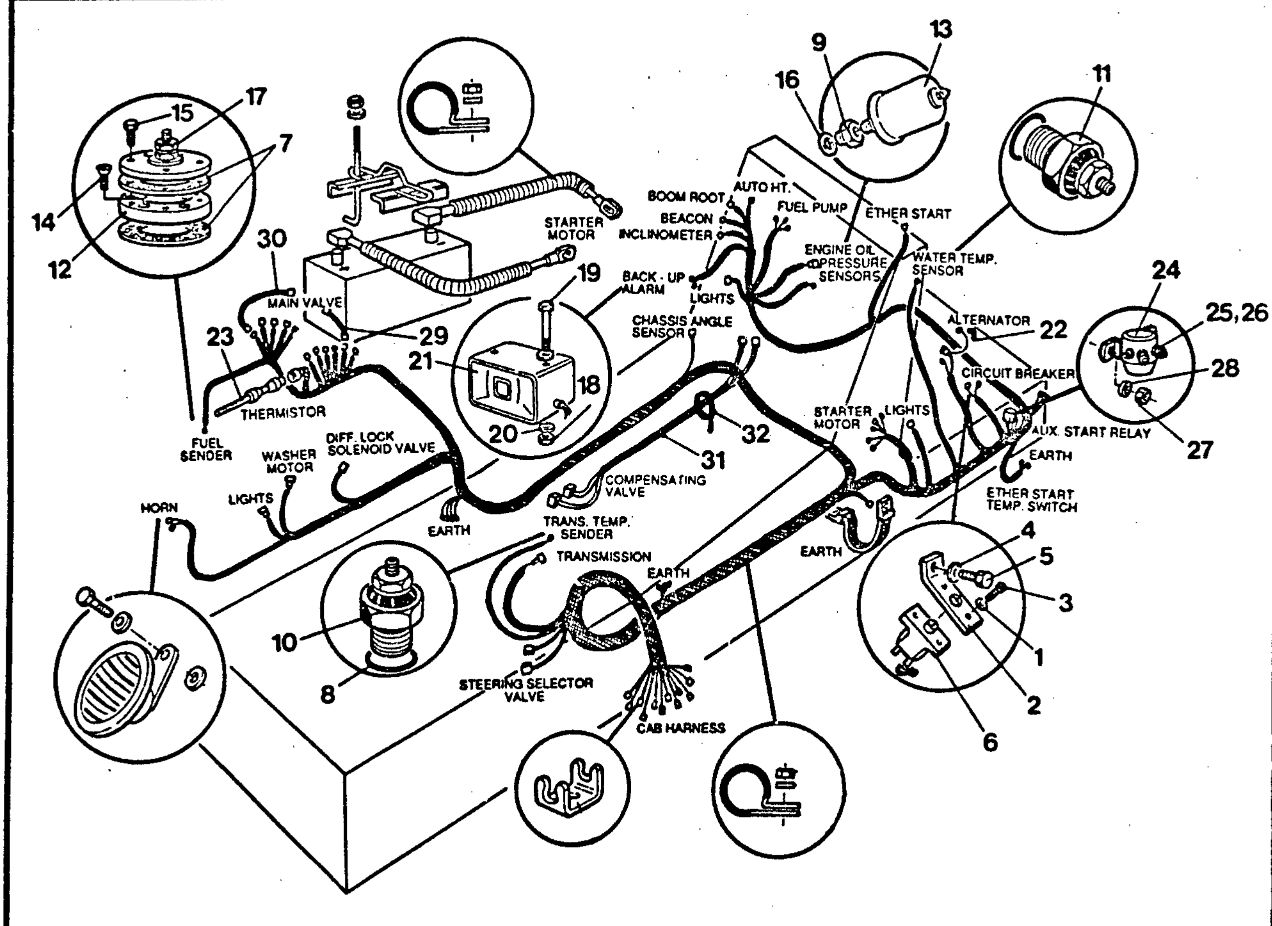
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	20	897365	1	SPECIAL WASHER
M	21	8T4138	1	BOLT
M	22	8T4205	1	WASHER
	23	908133	1	HORN AS.
	24	3T5760	1	BATTERY 12V.
	25	5U2659	2	STUD
	26	6V8801	2	NUT
	27	7X0578	2	WASHER
	28	9R0787	1	HOLDER AS.
	29	6R8930	1	CABLE AS. +VE TO STARTER
	30	6R8931	1	CABLE AS. -VE TO STARTER
M	31	6V7743	7	NYLOC NUT
M	32	6V7744	1	SELF LOCKING NUT
	33	815930	1	CABLE AS. EARTH
M	34	8T4121	1	WASHER
M	35	8T4205	7	WASHER
	36	985714	7	P. CLIP 20mm DIA

F - NOT SHOWN
M - METRIC PART

P6R7742 Y
REV 006

6R7742 ELECTRICAL GROUP - CHASSIS. (1 of 2)

ELECTRICAL EQUIPMENT



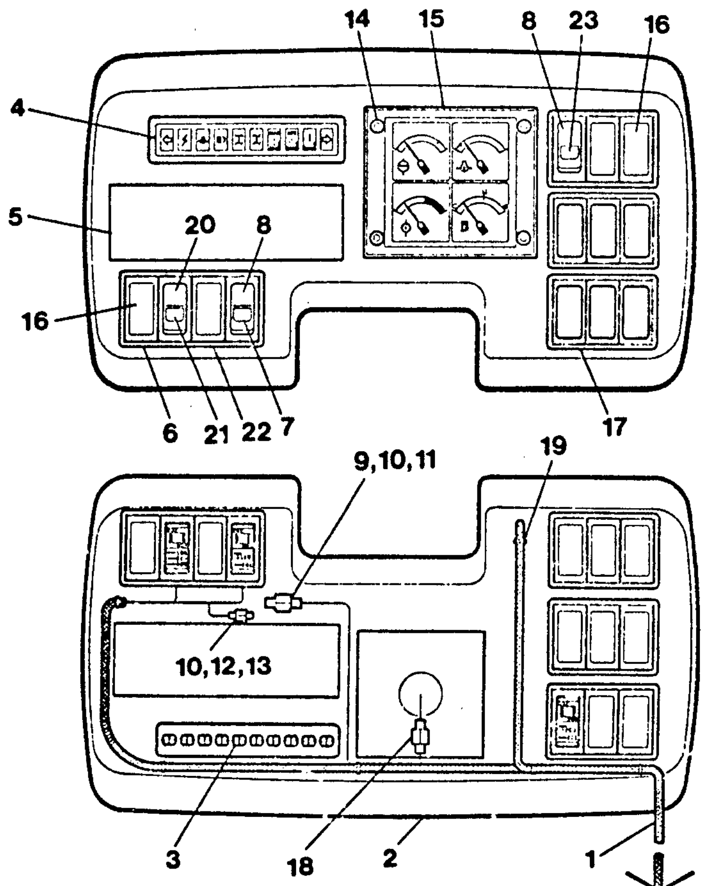
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	4B4863	2	WASHER		16	985800	1	COPPER WASHER
	2	6R9244	1	BRACKET - CIRCUIT BREAKER		17	9X0266	1	FUEL SENDER
	3	7D5473	2	SCREW		18	6V9189	2	NYLOC NUT
M	4	8T4224	1	WASHER	M	19	7X2538	2	BOLT
M	5	8T6912	1	BOLT	M	20	8T4224	2	WASHER
	6	9S0173	1	CIRCUIT BREAKER		21	922742	1	ALARM
	7	302030	2	GASKET		22	918688	1	BOOT
	8	3J1907	1	O. RING		23	985626	1	THERMISTOR AS.
	9	3Y2888	1	CONECTOR		24	302266	1	SWITCH
	10	4W9972	1	GAUGE - T.C TEMP SENDER		25	4B2043	2	NUT
	11	4W9972	1	GAUGE - WATER TEMP SENDER		26	4F2294	2	NUT
	12	6R9266	1	ADAPTOR - FUEL SENDER	M	27	6V7743	2	NYLOC NUT
	13	7W2938	1	OIL PRESSURE SENDER	M	28	8T4205	2	WASHER
M	14	815527	5	SCREW		29	6R7805	1	HARNESS ASSY - FRAME UP SOL
	15	8T0287	5	BOLT		30	6R7806	1	HARNESS ASSY - FRAME DOWN SOL
						31	8Q2460	1	HARNESS ASSY - COMP. MANIFOLD
						32	985708	4	CABLE TIE

M - METRIC PART

P6R7742 Y
REV 006

6R7742 ELECTRICAL GROUP - CHASSIS. (2 of 2)

ELECTRICAL EQUIPMENT



VIEW ON REAR OF PANEL

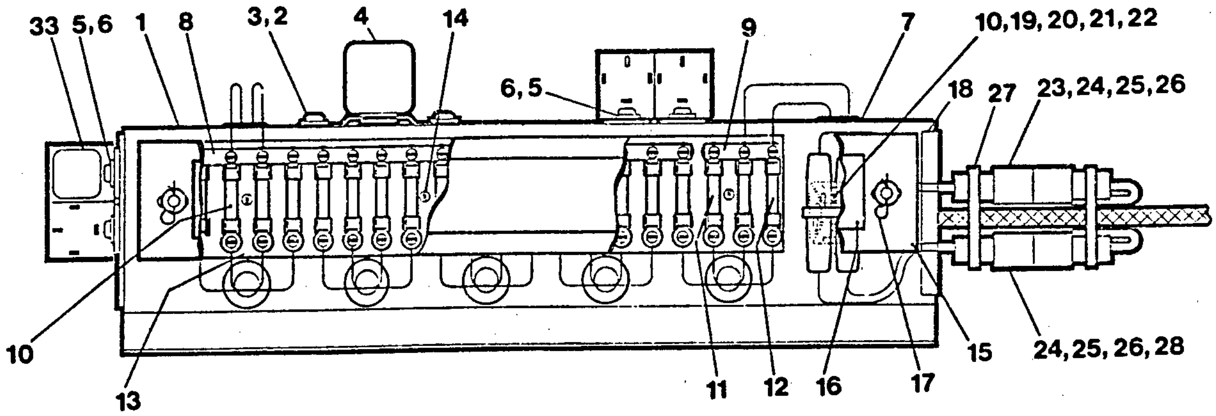
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7796	1	HARNESS AS - DASHPANEL		13	9G2264	1	SURESEAL CLIP
	2	6R7539	1	INSTRUMENT BINNACLE AS	M	14	8T0257	4	SCREW
	3	844375	10	BULB		15	9X5715	1	GAUGE PACK
	4	844377	1	WARNING LIGHT CLUSTER		16	6U5794	10	BLANKING PLATE
	5	844376	1	RADIO BLANK		17	898089	3	MOUNTING FRAME -3 SWITCH
	6	844378	2	1 WAY SWITCH FRAME		18	9G3659	1	SURESEAL CLIP
	7	6R9004	1	MOTION BOOST PLATE		19	985708	10	CABLE TIE
	8	844203	2	SINGLE ON/OFF ILLUMINATION		20	844198	1	SWITCH
	9	9G3671	1	6 PIN SURESEAL PLUG		21	844108	1	PLATE - SUPPLEMENTAL STEER
	10	9G3695	8	SURESEAL SEALING PLUG		22	6R7480	2	1 WAY SWITCH FRAME
	11	9G3658	1	POWER SURESEAL CLIP		23	6R9005	1	BUCKET PLATE
	12	7N9737	1	2 PIN SURESEAL PLUG					

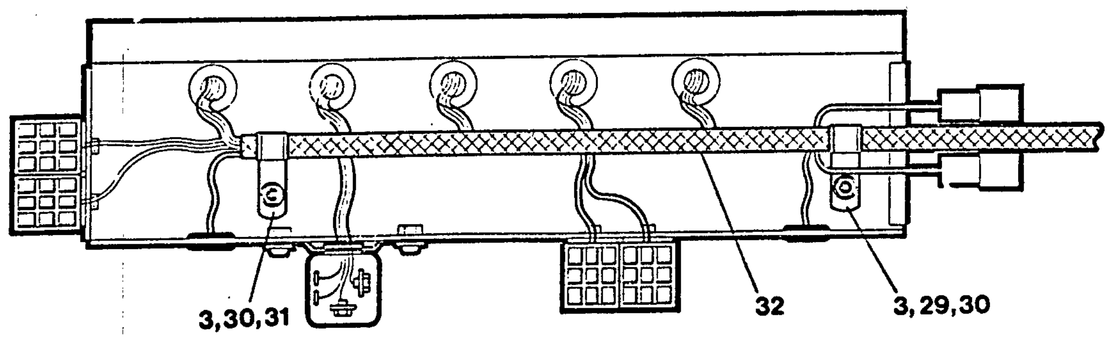
M - METRIC PART

P6R8993 Y

REV 001

6R8993 ELECTRICAL GROUP - DASHPANEL





VIEW ON UNDERSIDE OF PANEL

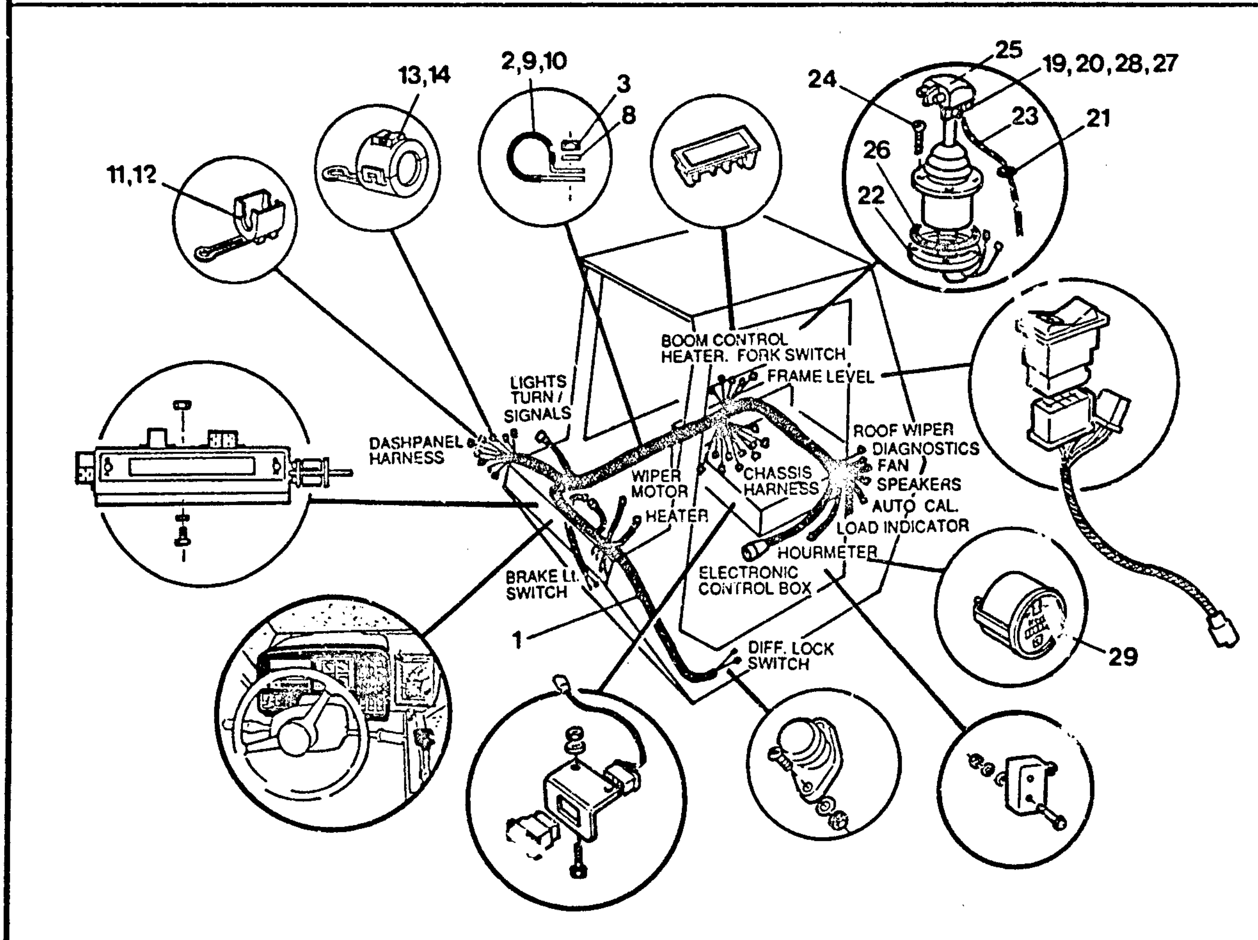
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	844175	1	FUSE PANEL AS	D	18	898054	0.85	EDGING STRIP
M	2	8T6411	2	SCREW		19	844170	2	IN LINE FUSE HOLDER
M	3	8T4205	4	WASHER		20	844190	1	CABLE TIE
	4	815801	1	RELAY SINGLE POLE		21	844171	1	CABLE TIE MOUNT
M	5	6V9673	4	SCREW	M	22	6V9671	2	SCREW
M	6	6V7699	4	WASHER		23	7N9738	1	PLUG
	7	2S9727	7	GROMMET		24	7N7779	2	SOCKET
	8	6R7804	1	BUS - BAR 17 WAY		25	7N7780	2	PIN
	9	985700	1	BUS BAR 3 WAY		26	9G2264	2	SURESEAL CLIP
	10	3K8782	20	FUSE 10AMP		27	985708	2	CABLE TIE
	11	8M0456	1	FUSE 20AMP		28	7N9737	1	2 PIN SURESEAL PLUG
	12	8M8948	1	FUSE 15A		29	81[illegible]917	1	P - CLIP
	13	3V4784	2	FUSE HOLDER	M	30	6V7743	2	NYLOC NUT
M	14	816373	4	SCREW		31	985714	1	P - CLIP
	15	844178	1	COVER		32	6R7802	1	HARNESS AS - FUSE & RELAY
	16	6R7909	1	FILM-FUSE IDENTIFICATION		33	6R8994	1	BUZZER
	17	6V9197	2	PIII LOCK (R. CLIP)					

M - METRIC PART
D - ORDER BY THE METRE

P6R7803 Y
REV 000

6R7803 FUSE & RELAY PANEL
Part of 6R7913 Electrical Group - Cab

ELECTRICAL EQUIPMENT



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7793	1	HARNESS AS. - CAB	F	–	9G3671	2	SURESEAL PLUG 6 PIN
	2	6R9240	7	P. CLIP	F	–	9G3672	1	SURESEAL PLUG 5 PIN
M	3	6V7743	15	NYLOC NUT	F	–	9G3678	1	SURESEAL RECEPTACLE 5 WAY
F	-	7N7782	1	SURESEAL PLUG 3 PIN	F	–	9G3695	43	SURESEAL SEALING PLUG
F	-	7N8204	1	SURE SEAL SOCKET 4 PIN		19	3K0835	1	LOCKNUT
F	-	7N8205	3	SURESEAL PLUG 4PIN		20	6F0253	1	LOCKWASHER
F	-	7N9737	1	SURESEAL PLUG 2 PIN		21	6K8180	1	GROMMET
M	8	8T4205	15	WASHER		22	6R7629	1	RETAING RING
	9	985714	4	P. CLIP 20MM		23	6R9189	1	HARNESS AS - JOYSTICK
	10	985721	2	P. CLIP 12.7MM	M	24	6V9491	4	SCREW
	11	9G2264	5	SURESEAL CLIP	Y	25	838886	1	JOYSTICK CONTROLLER
	12	9G2265	9	SURESEAL CLIP		26	844091	1	RUBBER RING
	13	9G3658	18	POWER SURESEAL CLIP		27	8T8744	1	SWITCH
	14	9G3659	11	SURESEAL CLIP	E	28	985625	8.0	SLEEVING-1.6MM
						29	6T7337	1	HOUR METER

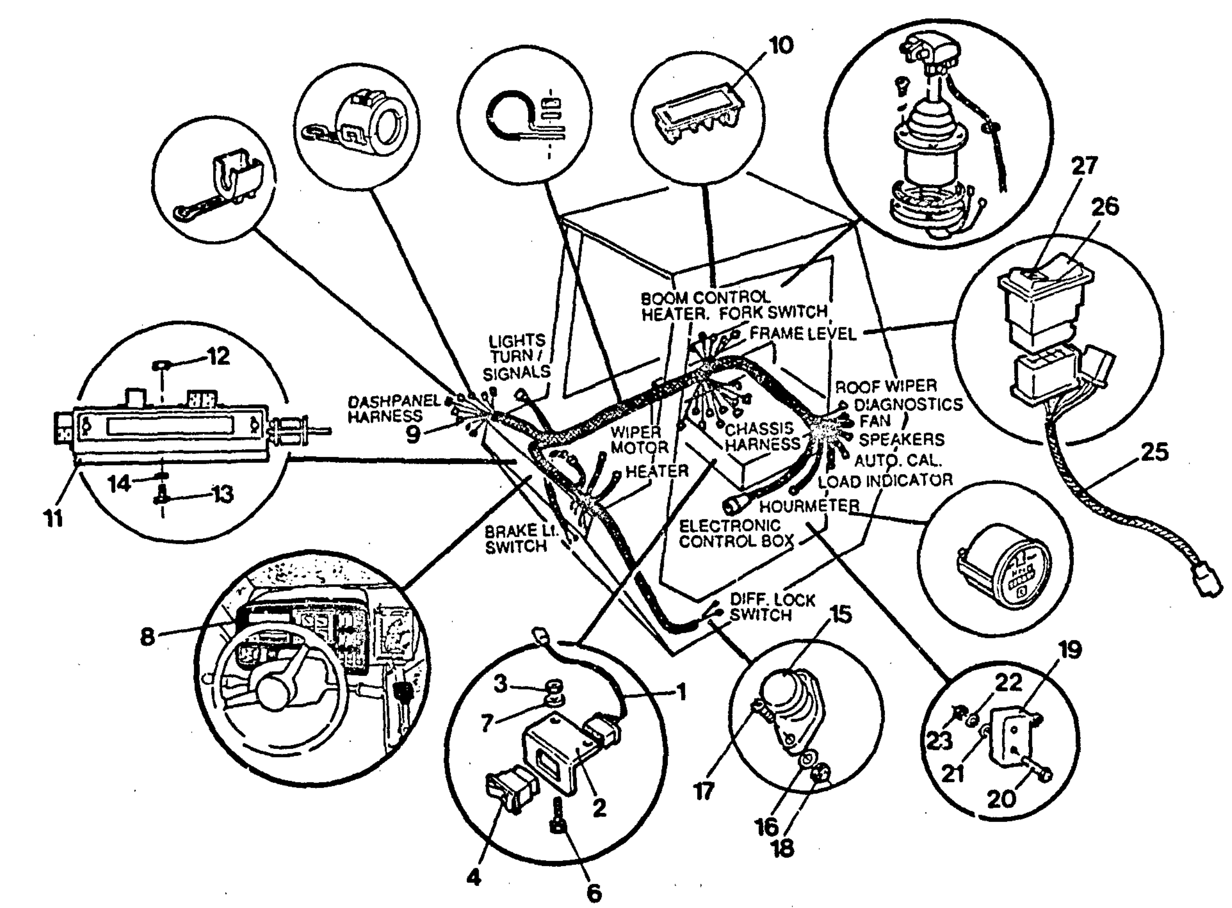
F - NOT SHOWN
Y - SEPARATE ILLUSTRATION

E - ORDER BY THE CENTIMETER
M - METRIC PART

P6R7913 Y
REV 008

6R7913 ELECTRICAL GROUP CAB (1of2)
838886 - PAGE
Part of 6R7740 Open Cab Group

ELECTRICAL EQUIPMENT



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R8986	1	HARNESS - AUTO CAL SWITCH		15	6R7483	1	SWITCH
	2	6R8987	1	BRACKET	M	16	6V9499	2	WASHER
M	3	6V7743	2	NYLOC NUT	M	17	6V9672	2	SCREW
	4	815807	1	SWITCH	M	18	8T7961	2	NYLOC NUT
YNSS	F	838946	1	ELECTRONIC CONTROL BOX GROUP		19	6R7718	1	MICROSWITCH
	6	8T4171	2	BOLT	M	20	6R9354	2	SCREW
	7	8T4205	2	WASHER	M	21	6V7699	4	WASHER
YNSS	8	6R8988	1	DASHPANEL GROUP	M	22	6V9497	2	WASHER
	9	6R9337	1	SHORTING PLUG	M	23	8T2658	2	NYLOC NUT
	10	6U5794	1	BLANKING PLATE		F	5L6688	1	BUTTON PLUG
YNSS	11	6R7803	1	ELEC GROUP-FUSE & RELAY PANEL		25	6R7583	1	HARNESS AS. - FRAME LEVEL SW.
	12	6V7743	5	NYLOC NUT		26	6R7807	1	SWITCH
M	13	8T4171	5	BOLT		27	844109	1	PLATE - YELLOW
M	14	8T4205	5	WASHER					

F - NOT SHOWN
Y - SEPARATE ILLUSTRATION

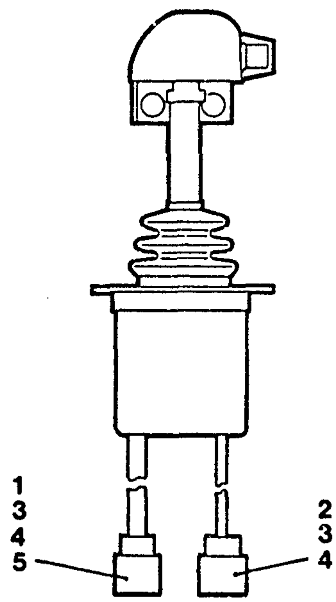
NSS - NOT SERVICED
M - METRIC PART

P6R7913 Y
REV 008

6R7913 ELECTRICAL GROUP CAB (2of2)

838946 - PAGE 263, 6R8988 - PAGE 239, 6R7803 - PAGE 258.

ELECTRICAL EQUIPMENT

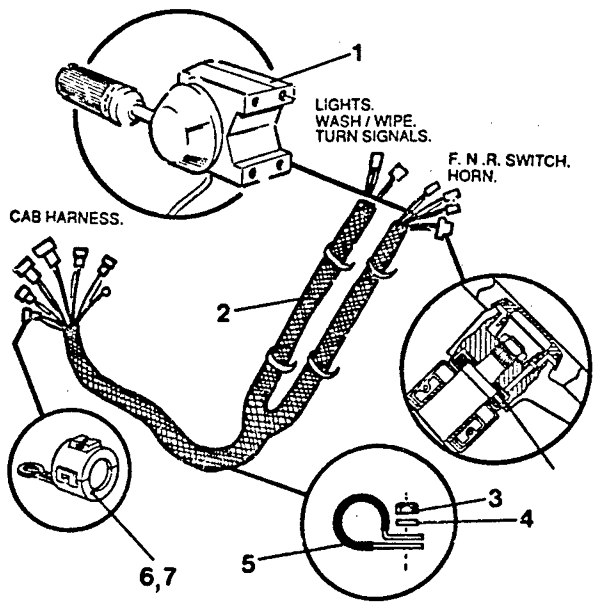


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9G3669	1	HOUSING
	2	7N8205	1	HOUSING
	3	7N7779	5	SOCKET
	4	7N7780	6	PIN
	5	9G3695	1	SEALING PLUG

P838886 Y
REV000

838886 JOYSTICK GROUF
Part of 6R7913 Electrical GP - Cab

ELECTRICAL EQUIPMENT



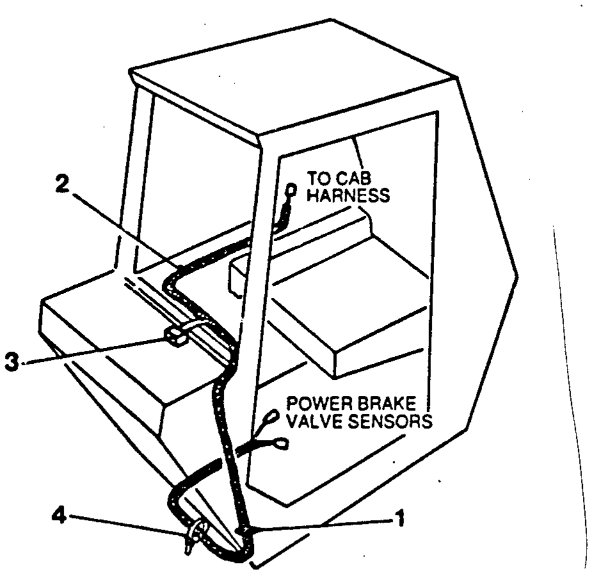
NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	3E3499	1	CONTROL GROUP-TRANSMISSION
	2	6R7794	1	HARNESS AS. - STEER COLUM
M	3	6V7743	4	NYLOC NUT
M	4	8T4205	4	WASHER
	5	985714	4	P. CLIP
	6	9G3358	3	POWER SURESEAL CLIP
	7	9G3659	2	SURESEAL CLIP
	8	835888	1	SWITCH AS. HORN
	F	9G3669	1	8 PIN SURESEAL PLUG
	F	9G3672	1	5 PIN SURESEAL PLUG
	F	9G3695	13	SURESEAL SEALING PLUG

M - METRIC PART
F - NOT SHOWN

P6R9018 Y
REV 002

6R9018 ELECTRICAL GROUP - STEERING COLUMN
3E3499 - PAGE 101

ELECTRICAL EQUIPMENT

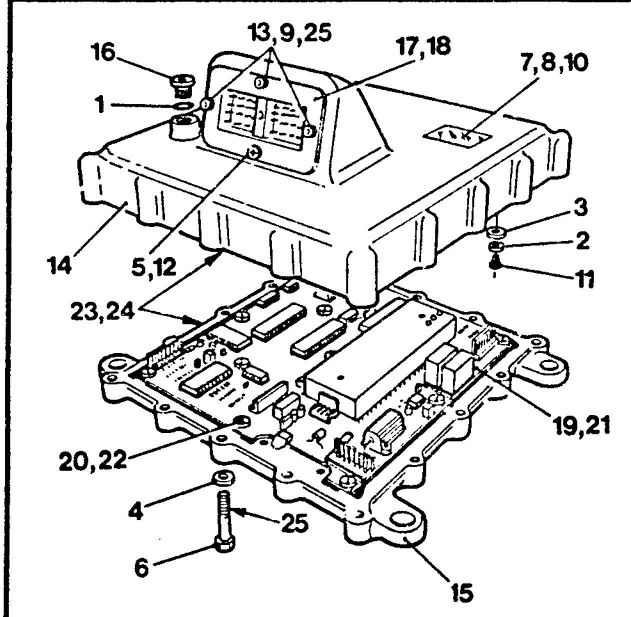


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	5P8131	1	GROMMET
	2	8Q2462	1	HARNESS ASSY-POWER BRAKE
	3	8Q2469	1	BUZZER - POWER BRAKE
	4	985708	2	CABLE TIE

P8Q2703 Y
REV000

8Q2703 ELECTRICAL GROUP - POWER BRAKE

ELECTRICAL EQUIPMENT



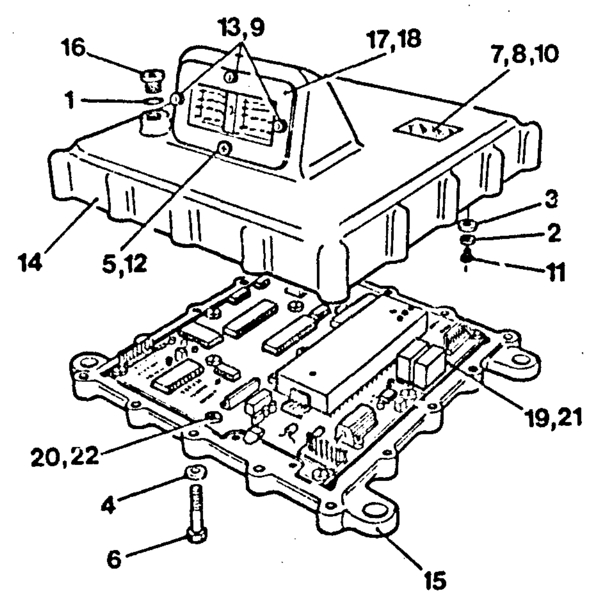
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3J7354	1	O RING (O.R.B.)
	2	3L8187	4	LOCKWASHER
	3	4B4863	4	WASHER
M	4	5P0537	16	WASHER
	5	6V9491	1	SCREW
	6	7B2742	16	BOLT
	7	8C5634	1	LENS
	8	8C6024	1	SEAL
	9	8C9660	3	WASHER
	10	8C9756	4	SPACER
	11	8F5734	4	SCREW
M	12	8T2659	1	SELF LOCKING NUT
M	13	8T3998	3	SOCKET HEAD SCREW
	14	NSS	1	LID
	15	NSS	1	BASE
	16	9S8002	1	PLUG
	17	8T9833	1	CONNECTOR
	18	041963	1	SEAL
	19	1P2086	2	BOLT
	20	8C8515	11	SCREW
	21	NSS	1	PRINTED CIRCUIT BOARD MK3
	22	8F1434	13	LOCKWASHER
B	23	6V1541	—	PRIMER
B	24	6V5765	—	SEALANT
B	25	9S3263	—	SEALANT

NSS - NOT SERVICED
M - METRIC PART
B - USE AS REQUIRED

P838946 Y
REV 003

838946 ELECTRONIC CONTROL BOX GROUP
Part of 6R7913 Electrical Group - Cab

ELECTRICAL EQUIPMENT (AN ATTACHMENT)



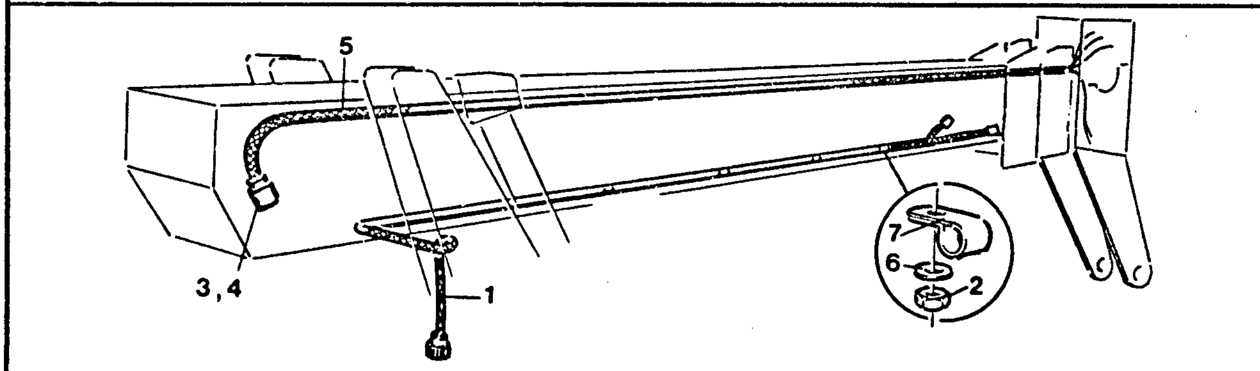
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	3J7354	1	O RING (O.R.B.)
	2	3L8187	4	LOCKWASHER
	3	4B4863	4	WASHER
M	4	5P0537	16	WASHER
	5	6V9491	1	SCREW
	6	7B2742	16	BOLT
	7	8C5634	1	LENS
	8	8C6024	1	SEAL
	9	8C9660	4	WASHER
	10	8C9756	4	SPACER
	11	8F5734	4	SCREW
M	12	8T2659	1	SELF LOCKING NUT
M	13	8T3998	[illegible]	SOCKET HEAD SCREW
	14	NSS	[illegible]	LID
	15	NSS	1	BASE
	16	9S8002	1	PLUG
	17	8T9933	1	CONNECTOR
	18	041963	1	SEAL
	19	1P2086	2	BOLT
	20	8C8515	11	SCREW
	21	NSS	1	PRINTED CIRCUIT BOARD
	22	8F1434	11	LOCKWASHER

NSS - NOT SERVICED
M - METRIC PART

P6R8995 Y
REV 002

6R8995 ELECTRONIC CONTROL BOX GROUP
Part of 838836 Auto Height/ Reach GP

ELECTRICAL EQUIPMENT



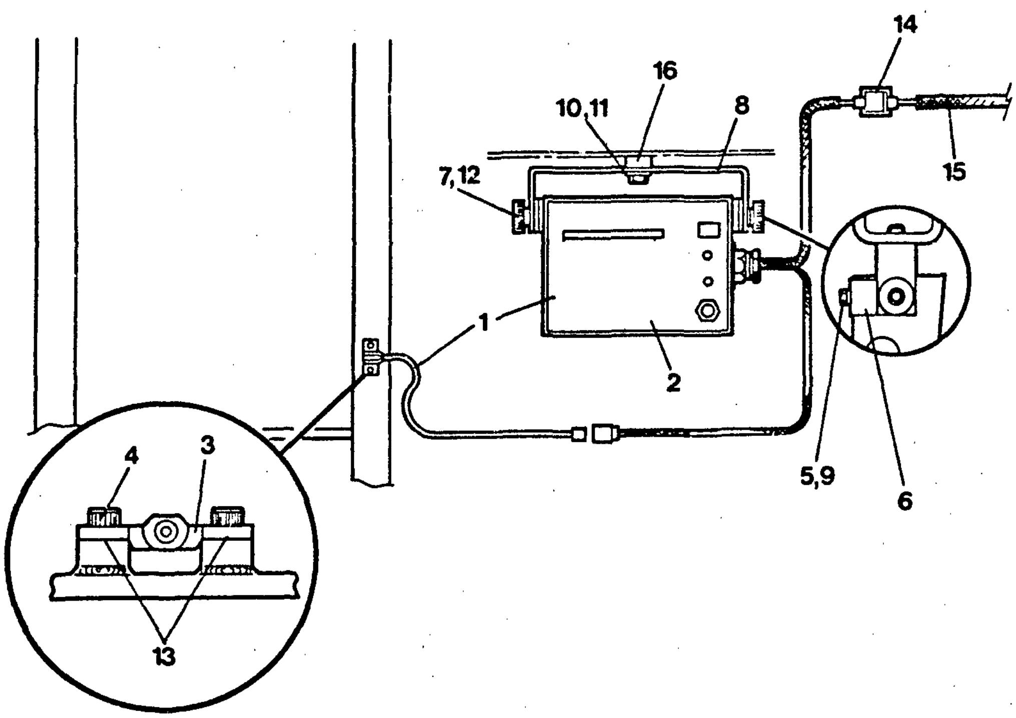
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9059	1	HARNESS AS.BOOM ROOT
M	2	6V7743	16	NYLOC NUT
	3	7N7779	2	SOCKET
	4	7N7780	2	PIN
	5	816356	1	HARNESS AS. BOOM HEAD
M	6	8T4205	16	WASHER
	7	985721	16	P. CLIP

M - METRIC PART

P844146 Y
REV 001

844146 ELECTRICAL GROUP - BOOM
Part of 985888 Three Section Boom Group (with Compensating Cylinders)

ELECTRICAL EQUIPMENT



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7948	1	LOAD INDICATOR GROUP KIT		7	816072	2	HANDWHEEL
	2	6R7848	1	DISPLAY UNIT		8	838623	1	BRACKET
	–	844241	1	STRAIN SENSOR GROUP	M	9	8T0287	2	BOLT
	3	985256	1	STRAIN SENSOR	M	10	8T4121	1	WASHER
	4	844242	2	CAP SCREW	M	11	8T4136	1	BOLT
M	5	6V7699	2	WASHER	M	12	8T4205	2	WASHER
	6	815914	1	BRACKET AS.	B	13	985214	–	ADHESIVE
						14	9G2264	1	SURESEAL CLIP
						15	844128	1	HARNESS - LOAD INDICATOR
						16	897338	1	SLEEVE

M - METRIC PART

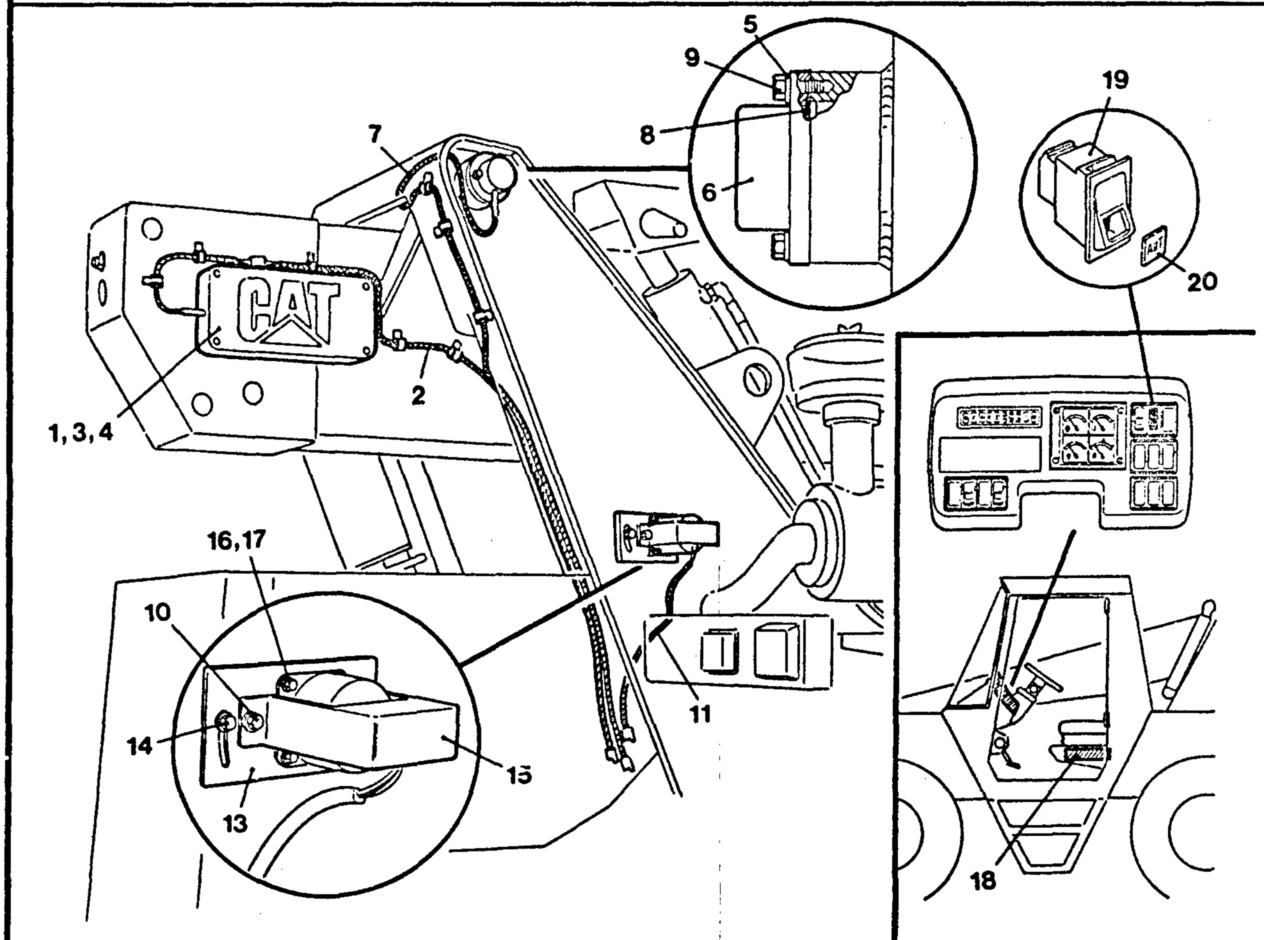
B - USE AS REQUIRED

P6R9162

REV 000

6R9162 LOAD INDICATOR GROUP (W.W.425)

ELECTRICAL EQUIPMENT (AN ATTACHMENT)



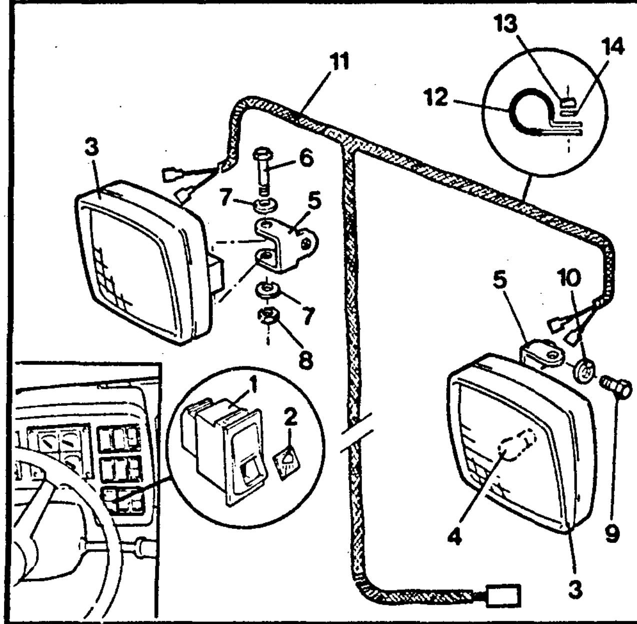
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7797	1	LENGTH SENSOR
	2	6R7799	1	HARNESS AS - LENGTH SENSOR
M	3	8T4224	3	WASHER
M	4	8T7547	3	BOLT
M	5	5P0537	2	WASHER
	6	6R7773	1	BOOM ANGLE SENSOR
	7	6R7776	1	HARNESS AS-BOOM ANGLE SENSOR
	8	6R7911	1	O RING
M	9	8T4971	2	BOLT
M	10	5C9553	2	BOLT

NOTE	REF NO	PART NUMBER	QTY	PART NAME
	11	6R7777	1	HARNESS AS-INCLINOMETER
	12	6R7800	1	INCLINOMETER
	13	6R9065	1	INCLINOMETER MOUNTING PLATE
M	14	7X2619	1	BOLT
	15	8Q2081	1	INCLINOMETER COVER AS
M	16	8T0287	4	BOLT
M	17	8T0328	4	WASHER
Y	18	6R8995	1	ELECTRONIC BOX- AUTO HEIGHT
	19	6R9011	1	SWITCH
	20	6R9012	1	AUTO HEIGHT PLATE

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P838836 Y
REV003

ELECTRICAL EQUIPMENT (AN ATTACHMENT)



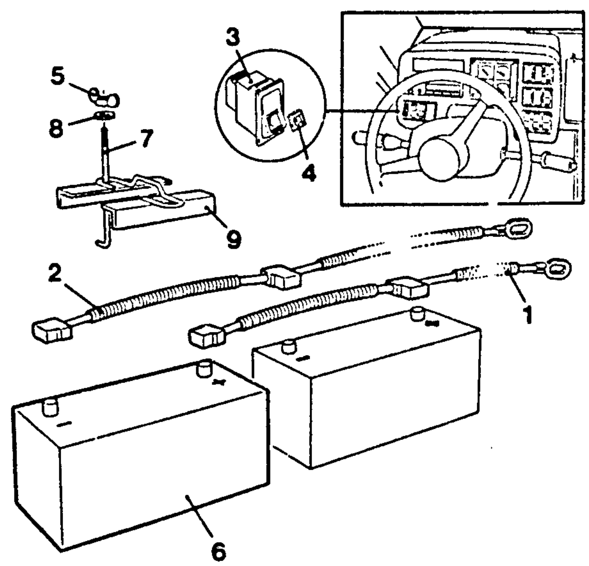
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	844203	1	SWITCH
	2	844214	1	PLATE - WORK LAMPS
	3	9W1001	2	WORK LAMP
	4	9W0607	2	BULB
	5	985532	2	BRACKET
M	6	NSS	2	BOLT
M	7	NSS	4	WASHER
M	8	NSS	2	NUT
M	9	NSS	2	BOLT
M	10	NSS	2	WASHER
	11	6R9061	1	HARNESS - WORK LAMP
	12	815918	5	CLIP
M	13	6V7743	5	NUT SELF LOCKING
M	14	8T4205	5	WASHER

M - METRIC PART
NSS - NOT SERVICED

P838831
REV 000

838831 BOOM WORK LAMP GROUP (WITH BOOM SERVICES)

ELECTRICAL EQUIPMENT (AN ATTACHMENT)



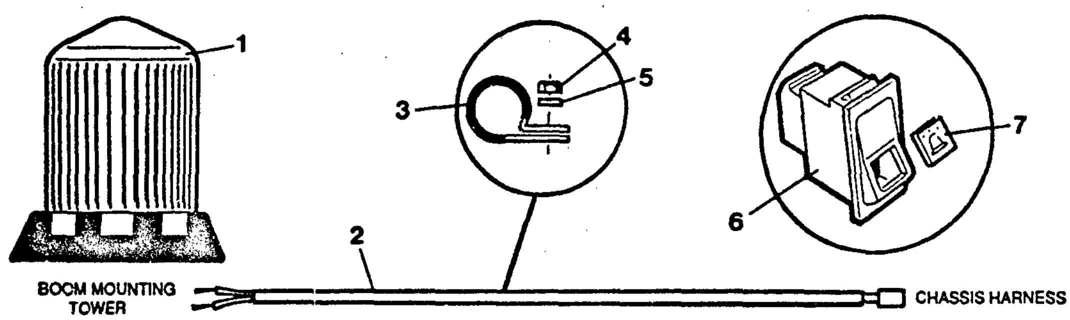
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R9047	1	CABLE AS:+VE TO STARTER
	2	6R9048	1	CABLE AS:-VE TO STARTER
	3	844199	1	SINGLE POLE ON/OFF MOM.
	4	898090	1	PLATE - COLD START SYMBOL
	5	2B9498	2	WING NUT
	6	3T5760	1	BATTERY 12V.
	7	5U2659	2	STUD
M	8	7X0578	2	WASHER
	9	9R0787	1	HOLDER AS
NSSY	F	816263	1	ETHER START GROUP

M - METRIC PART   F - NOT SHOWN
Y - SEPARATE ILLUSTRATION   NSS - NOT SERVICED

P838837 Y
REV001

838837 COLD START GROUP
816263 - PAGE

ELECTRICAL EQUIPMENT (AN ATTACHMENT)



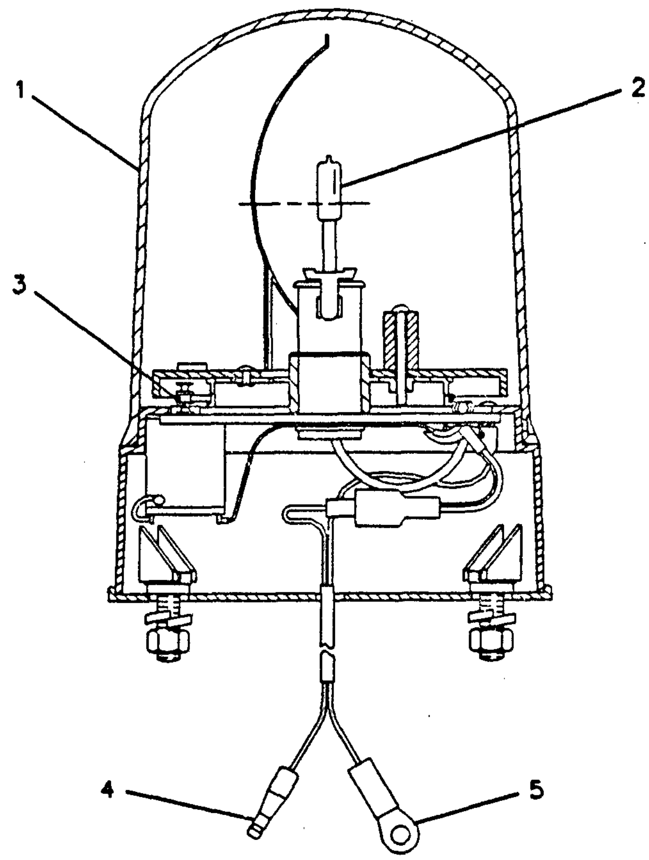
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
Y	1	9R8250	1	ROTATING BEACON G.P. (AMBER)					
	2	6R9021	1	HARNESS AS					
	3	815018	5	P - CLIP					
M	4	6V7743	5	NUT					
M	5	8T4205	5	WASHER					
	6	844203	1	SWITCH					
	7	844215	1	PLATE					

M - METRIC PART
Y - SEPARATE ILLUSTRATION

P6R7719 Y
REV 001

6R7719 ROTATING BEACON GROUP
9R8250 - PAGE 271

ELECTRICAL SYSTEM

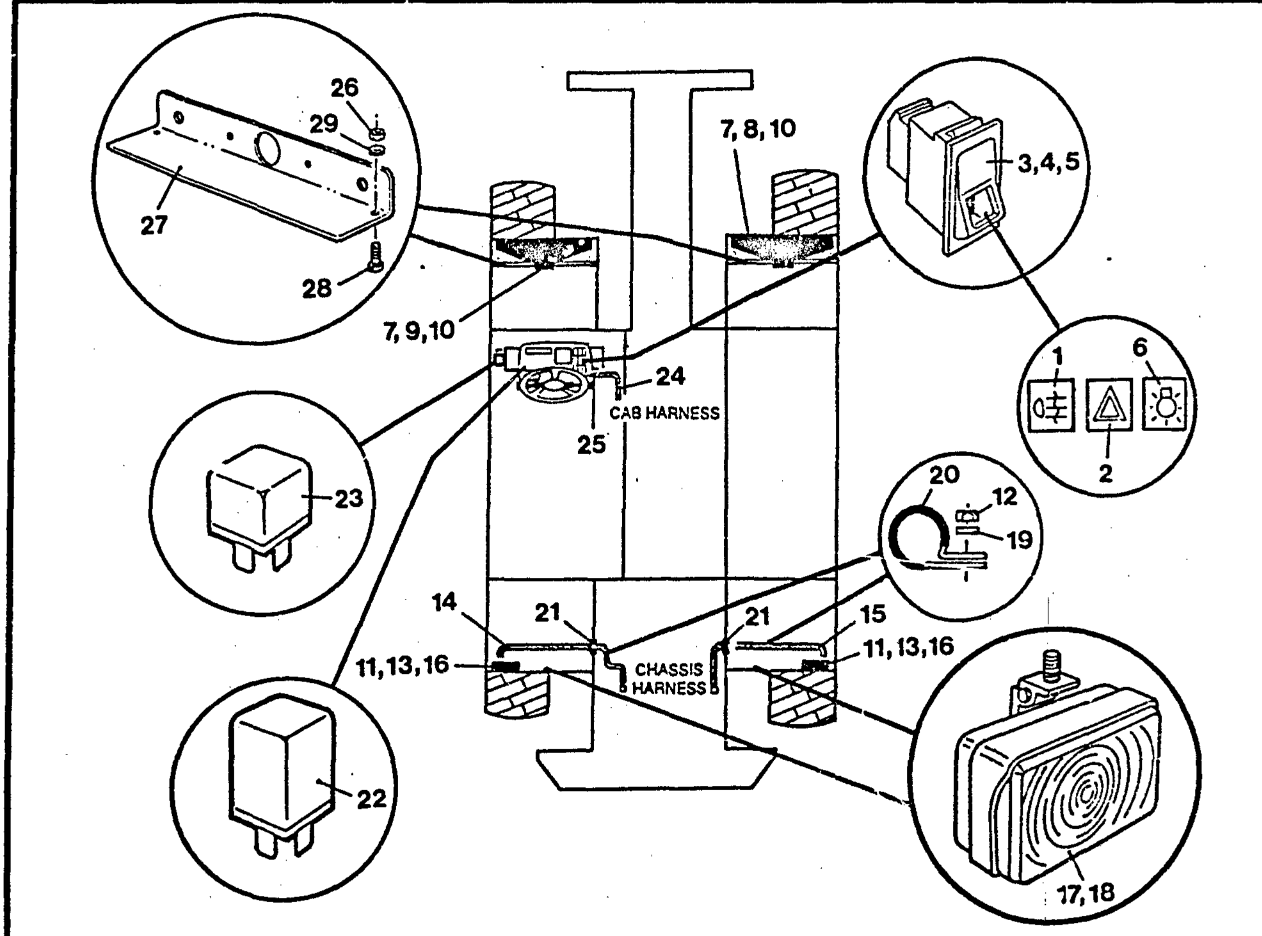


NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	9X8121	1	LENS-AMBER					
	2	9X8118	1	BULB					
	3	9X8139	1	BELT-DRIVE					
	4	6K1827	1	CONNECTOR-BULLET					
	5	2L8079	1	TERMINAL					

R-512988 EP

SR8250 LAMP GP-ROTATING WARNING
12 Volt Amber
Part of 6R7719 Rotating Beacon Group

ELECTRICAL EQUIPMENT(AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6U5791	1	PLATE-REAR FOG	Y	16	815954	2	LAMP STOP/TAIL/DIRECTION INDC
	2	815811	1	PLATE-HAZARD	Y	17	815957	1	REVERSING LAMP
	3	844201	1	HAZARD SWITCH ILLUMINATION	Y	18	815958	1	REAR FOG LAMP
	4	844202	1	LIGHT SWITCH ILLUMINATION	M	19	8T4205	4	WASHER
	5	844203	1	SINGLE ON/OFF ILLUMINATION		20	985721	4	P CLIP
	6	844213	1	PLATE - LIGHTING		21	2S1074	2	GROMMET
M	7	6V7743	4	NUT SELF LOCKING		22	844168	1	FLASHER UNIT
Y	8	815984	1	R.H FRONT LIGHT GROUP		23	844167	1	RELAY
Y	9	815985	1	L.H. FRONT LIGHT GROUP		24	815967	1	HARNESS AS. BRAKE LT SWITCH
M	10	8T4205	4	WASHER		25	844065	1	BRAKE LIGHT SWITCH
M	11	6V7699	4	WASHER	M	26	6V7743	8	NUT SELF LOCKING
M	12	6V7743	4	NUT SELF LOCKING		27	844122	2	BRACKET - LIGHT GROUP
M	13	6V9188	4	NUT SELF LOCKING	M	28	8T4171	8	BOLT
	14	6R8915	1	HARNESS AS. REAR LIGHTS LH	M	29	8T4205	8	WASHER
	15	6R8916	1	HARNESS AS. REAR LIGHTS RH	F		2U4578	3	GROMMET (FRONT WINGS & TANK)
					F		2U4465	12	LUCAR CONNECTOR (FEMALE)

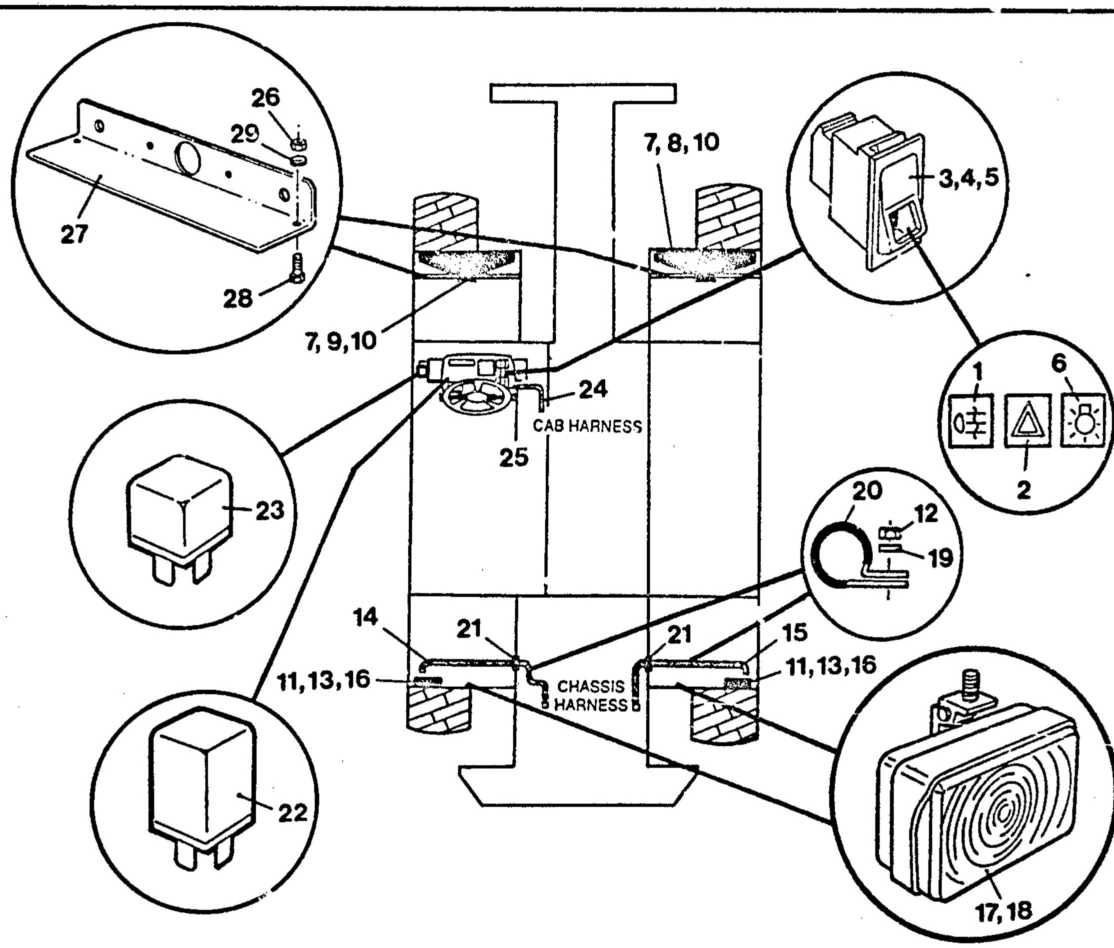
M - METRIC PART
Y - SEPARATE ILLUSTRATION
F - NOT SHOWN

P838835
REV 000

838835 ROAD LIGHTING GROUP - ALL WEATHER CAB ATTACHMENT - RIGHT HAND DIP

815984 - PAGE 277, 815985 - PAGE 277, 815954 - PAGE 278, 815957 - PAGE 279, 815958 - PAGE 279

ELECTRICAL EQUIPMENT(AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6U5791	1	PLATE-REAR FOG	Y	16	815954	2	LAMP STOP/TAIL/DIRECTION INDC
	2	815811	1	PLATE-HAZARD	Y	17	815957	1	REVERSING LAMP
	3	844201	1	HAZARD SWITCH ILLUMINATION	Y	18	815958	1	REAR FOG LAMP
	4	844202	1	LIGHT SWITCH ILLUMINATION	M	19	8T4205	4	WASHER
	5	844203	1	SINGLE ON/OFF ILLUMINATION		20	985721	4	P CLIP
	6	844213	1	PLATE - LIGHTING		21	2S1074	2	GROMMET
M	7	6V7743	4	NUT SELF LOCKING		22	844168	1	FLASHER UNIT
Y	8	815701	1	R.H FRONT LIGHT GROUP		23	844167	1	RELAY
Y	9	815702	1	L.H. FRONT LIGHT GROUP		24	815967	1	HARNESS AS. BRAKE LT SWITCH
M	10	8T4205	4	WASHER		25	844065	1	BRAKE LIGHT SWITCH
M	11	6V7699	4	WASHER	M	26	6V7743	8	NUT SELF LOCKING
M	12	6V7743	4	NUT SELF LOCKING		27	844122	2	BRACKET - LIGHT GROUP
M	13	6V9188	4	NUT SELF LOCKING	M	28	8T4171	8	BOLT
	14	6R8915	1	HARNESS AS. REAR LIGHTS LH	M	29	8T4205	8	WASHER
	15	6R8916	1	HARNESS AS. REAR LIGHTS RH	F		2U4578	3	GROMMET (FRONT WINGS & TANK)
					F		2U4465	12	LUCAR CONNECTOR (FEMALE)

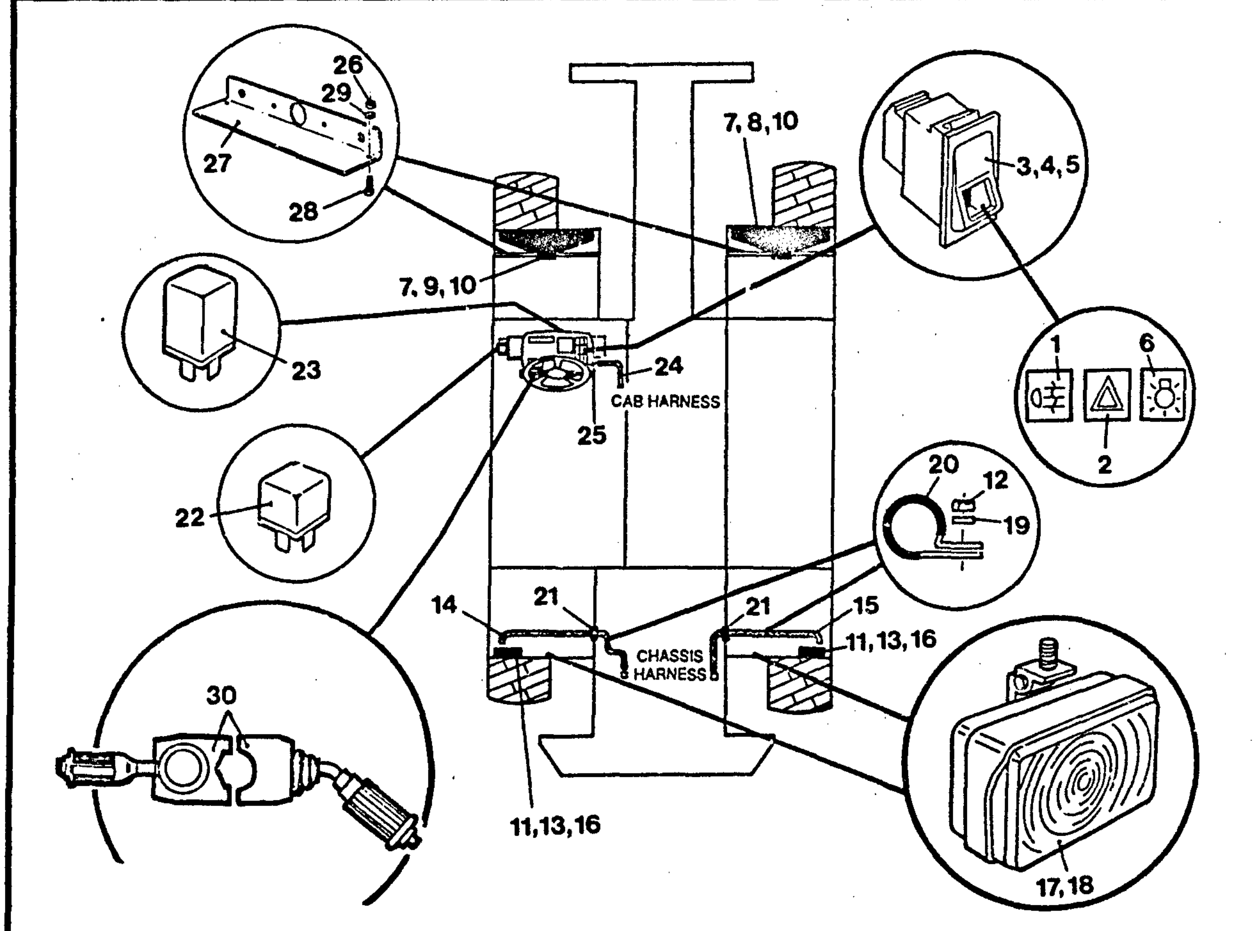
M - METRIC PART
Y - SEPARATE ILLUSTRATION
F - NOT SHOWN

P838833 Y
REV 000

838833 ROAD LIGHTING GROUP - ALL WEATHER CAB ATTACHMENT - LEFT HAND DIP

815701 - PAGE 276, 815702 - PAGE 276, 815954 - PAGE 278, 815957 - PAGE 279, 815958 - PAGE 279

ELECTRICAL EQUIPMENT(AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6U5791	1	PLATE-REAR FOG	Y	16	815954	2	LAMP STOP/TAIL/DIRECTION INDC
	2	815811	1	PLATE-HAZARD	Y	17	815957	1	REVERSING LAMP
	3	844201	1	HAZARD SWITCH ILLUMINATION	Y	18	815958	1	REAR FOG LAMP
	4	844202	1	LIGHT SWITCH ILLUMINATION	M	19	8T4205	4	WASHER
	5	844203	1	SINGLE ON/OFF ILLUMINATION		20	985721	4	P CLIP
	6	844213	1	PLATE - LIGHTING		21	2S1074	2	GROMMET
M	7	6V7743	4	NUT SELF LOCKING		22	844168	1	FLASHER UNIT
Y	8	815701	1	R.H FRONT LIGHT GROUP		23	844167	1	RELAY
Y	9	815702	1	L.H. FRONT LIGHT GROUP		24	815967	1	HARNESS AS. BRAKE LT SWITCH
M	10	8T4205	4	WASHER		25	844065	1	BRAKE LIGHT SWITCH
M	11	6V7699	4	WASHER	M	26	6V7743	8	NUT SELF LOCKING
M	12	6V7743	4	NUT SELF LOCKING		27	844122	2	BRACKET - LIGHT GROUP
M	13	6V9188	4	NUT SELF LOCKING	M	28	8T4171	8	BOLT
	14	6R8915	1	HARNESS AS. REAR LIGHTS LH	M	29	8T4205	8	WASHER
	15	6R8916	1	HARNESS AS. REAR LIGHTS RH		30	6R7918	1	STEER COLUMN SWITCH GROUP
						F	2U4578	3	GROMMET (FRONT WINGS & TANK)
						F	2U4465	12	LUCAR CONNECTOR (FEMALE)

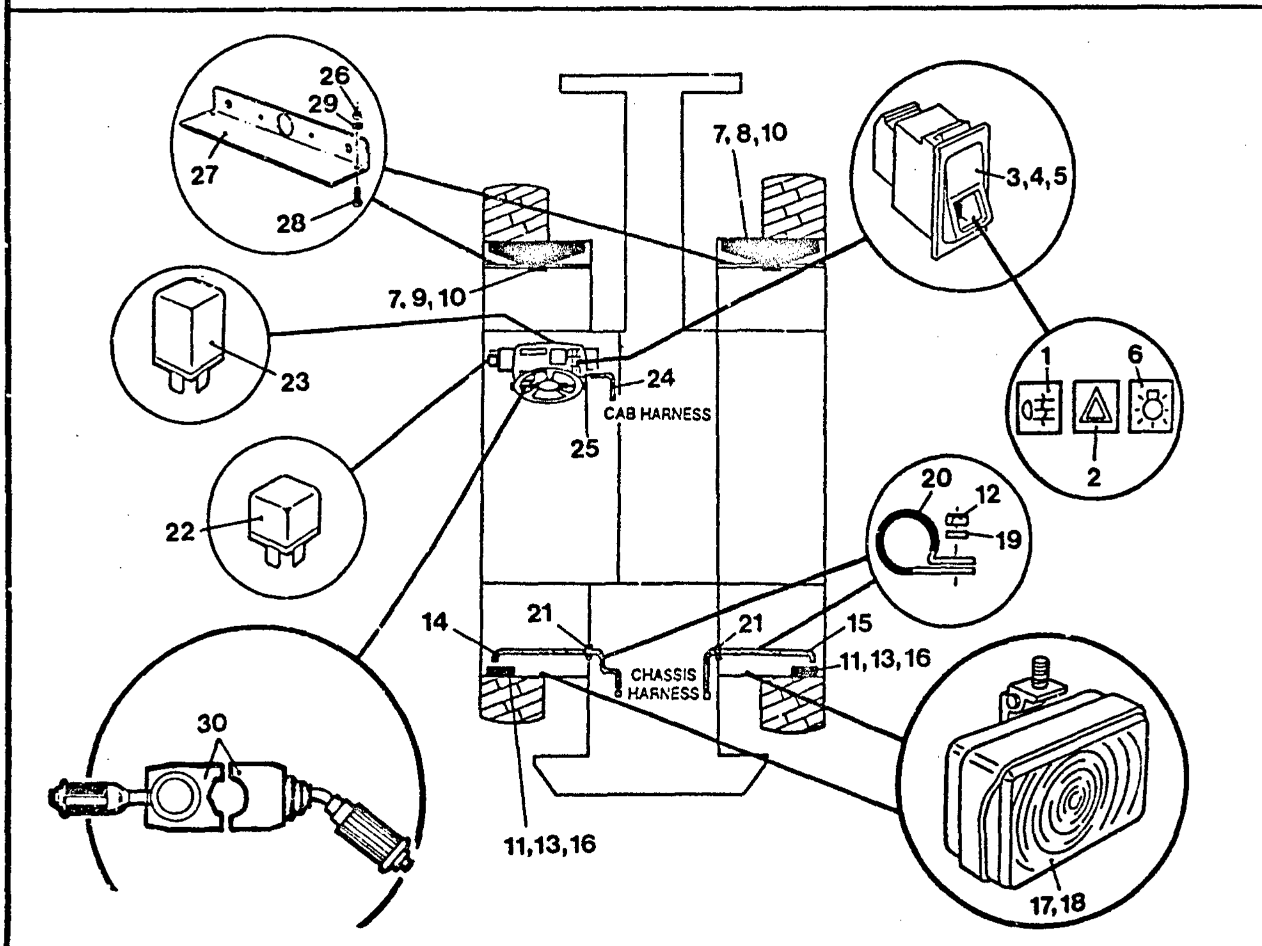
M - METRIC PART
Y - SEPARATE ILLUSTRATION
F - NOT SHOWN

P838832
REV 000

838832 ROAD LIGHTING GROUP - STANDARD CAB ATTACHMENT - LEFT HAND DIP

815701 - PAGE 276, 815702 - PAGE 276, 815954 - PAGE 278, 815957 - PAGE 279, 815958 - PAGE 279

ELECTRICAL EQUIPMENT(AN ATTACHMENT)



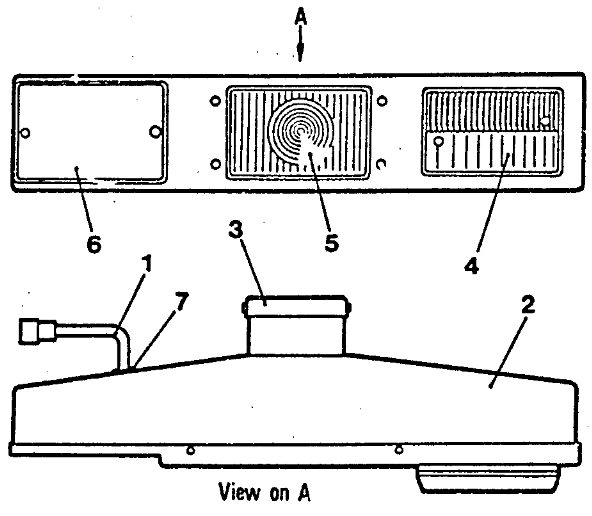
NOTE	REF NO	PART NUMBER	QTY	PART NAME	NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6U5791	1	PLATE-REAR FOG	Y	16	815954	2	LAMP STOP/TAIL/DIRECTION INDC
	2	815811	1	PLATE-HAZARD	Y	17	815957	1	REVERSING LAMP
	3	844201	1	HAZARD SWITCH ILLUMINATION	Y	18	815958	1	REAR FOG LAMP
	4	844202	1	LIGHT SWITCH ILLUMINATION	M	19	8T4205	8	WASHER
	5	844203	1	SINGLE ON/OFF ILLUMINATION		20	985721	8	P CLIP
	6	844213	1	PLATE - LIGHTING		21	2S1074	2	GROMMET
M	7	6V7743	4	NUT SELF LOCKING		22	844168	1	FLASHER UNIT
Y	8	815984	1	R.H FRONT LIGHT GROUP		23	844167	1	RELAY
Y	9	815985	1	L.H. FRONT LIGHT GROUP		24	815967	1	HARNESS AS. BRAKE LT SWITCH
M	10	8T4205	4	WASHER		25	844065	1	BRAKE LIGHT SWITCH
M	11	6V7699	4	WASHER	M	26	6V7743	8	NUT SELF LOCKING
M	12	6V7743	8	NUT SELF LOCKING		27	844122	2	BRACKET - LIGHT GROUP
M	13	6V9188	4	NUT SELF LOCKING	M	28	8T4171	8	BOLT
	14	6R8915	1	HARNESS AS. REAR LIGHTS LH	M	29	8T4205	8	WASHER
	15	6R8916	1	HARNESS AS. REAR LIGHTS RH		30	6R7918	1	STEER COLUMN SWITCH GROUP
						F	2U4578	3	GROMMET (FRONT WINGS & TANK)
						F	2U4465	12	LUCAR CONNECTOR (FEMALE)

M - METRIC PART
Y - SEPARATE ILLUSTRATION
F - NOT SHOWN

P838834 Y
REV 000

838834 ROAD LIGHTING GROUP - STANDARD CAB ATTACHMENT - RIGHT HAND DIP
815984 - PAGE 277, 815985 - PAGE 277, 815954 - PAGE 278, 815957 - PAGE 279, 815958 - PAGE 279

ELECTRICAL EQUIPMENT (AN ATTACHMENT)

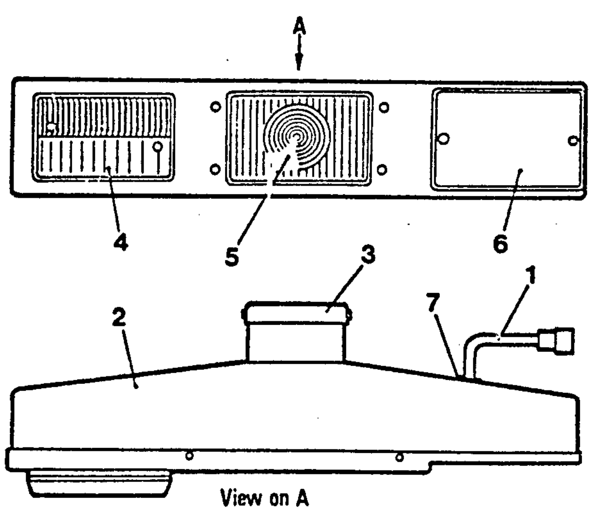


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815969	1	HARNESS
	2	815956	1	MOULDING
	3	815981	1	COVER
Y	4	815953	1	LAMP - SIDE/DIRECTION
Y	5	815979	1	LAMP - HEAD
	6	815983	1	COVER
	7	9L6074	1	GROMMET
	F	2C7834	1	GROMMET (CAB ENTRANCE)

F - NOT SHOWN Y - SEPARATE ILLUSTRATION P815702 REV 001

815702 LEFT FRONT LIGHT GROUP (LEFT HAND DIP)
Part of 838833 And 838832 Road Lighting Groups
815953 - PAGE 278, 815979 - PAGE 280.

ELECTRICAL EQUIPMENT (AN ATTACHMENT)

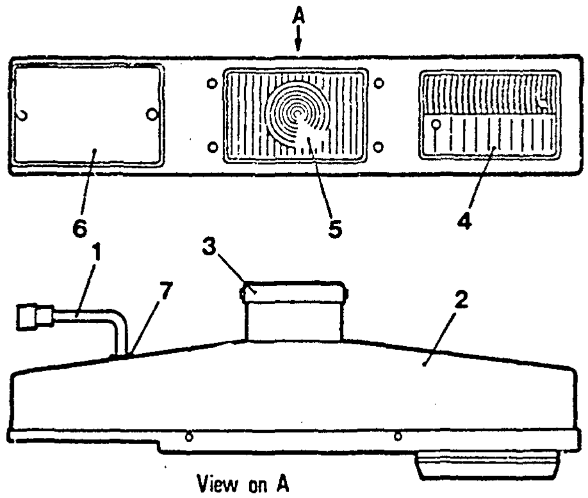


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815968	1	HARNESS
	2	815956	1	MOULDING
	3	815981	1	COVER
Y	4	815953	1	LAMP - SIDE/DIRECTION
Y	5	815979	1	LAMP - HEAD
	6	815983	1	COVER
	7	9L6074	1	GROMMET

Y - SEPARATE ILLUSTRATION P815701 REV 000

815701 RIGHT FRONT LIGHT GROUP (LEFT HAND DIP)
Part of 838833 And 838832 Road Lighting Groups
815953 - PAGE 278, 815979 - PAGE 280.

ELECTRICAL EQUIPMENT (AN ATTACHMENT)



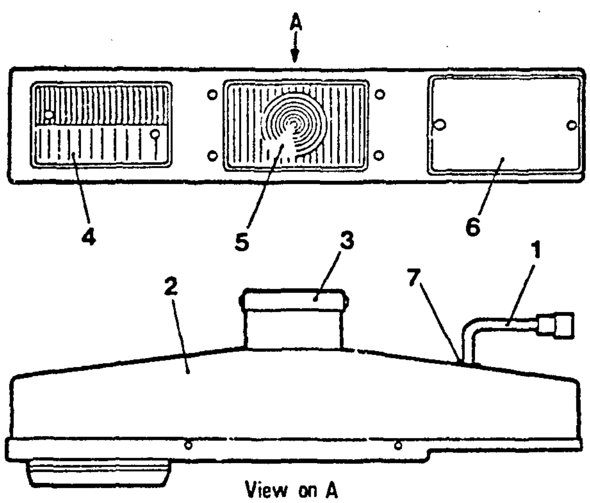
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815969	1	HARNESS
	2	815956	1	MOULDING
	3	815981	1	COVER
Y	4	815953	1	LAMP - SIDE/DIRECTION
Y	5	815980	1	LAMP - HEAD
	6	815983	1	COVER
	7	9L6074	1	GROMMET
	F	2C7834	1	GROMMET (CAB ENTRANCE)

F - NOT SHOWN
Y - SEPARATE ILLUSTRATION

P815985 Y
REV 001

815985 LEFT FRONT LIGHT GROUP (RIGHT HAND DIP)
Part of 838835 And 838834 Road Lighting Groups
815953 - PAGE 278, 815980 - PAGE 280.

ELECTRICAL EQUIPMENT (AN ATTACHMENT)



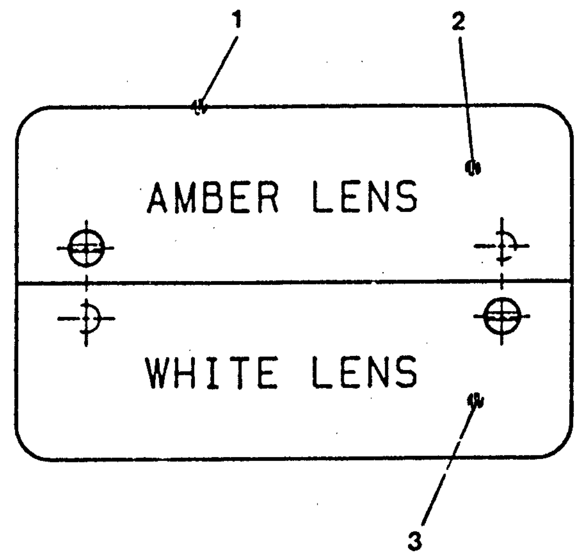
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	815968	1	HARNESS
	2	815956	1	MOULDING
	3	815981	1	COVER
Y	4	815953	1	LAMP - SIDE/DIRECTION
Y	5	815980	1	LAMP - HEAD
	6	815983	1	COVER
	7	9L6074	1	GROMMET

Y - SEPARATE ILLUSTRATION

P815984 Y
REV 000

815984 RIGHT FRONT LIGHT GROUP (RIGHT HAND DIP)
Part of 838835 And 838834 Road Lighting Groups
815953 - PAGE 278, 815980 - PAGE 280.

ELECTRICAL EQUIPMENT

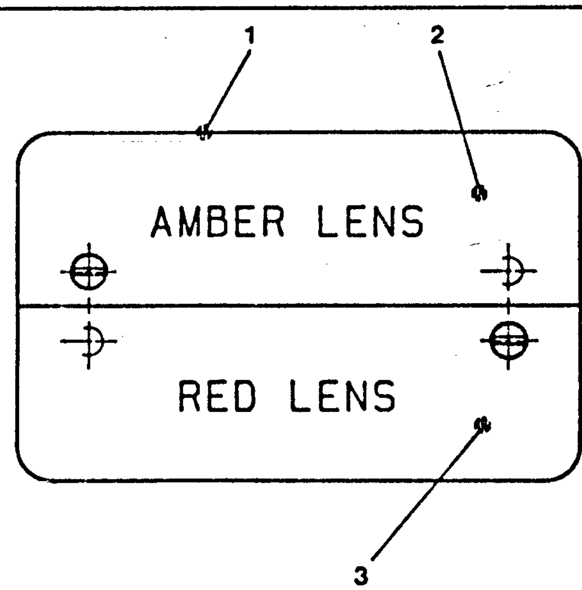


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7478	1	LENS
	2	844347	1	BULB
	3	844350	1	BULB

P815953
REV 001

815953 SIDE / DIRECTION INDICATOR LAMP
Part of 815985, 815984, 815702 And 815701 Front Light Groups

ELECTRICAL EQUIPMENT

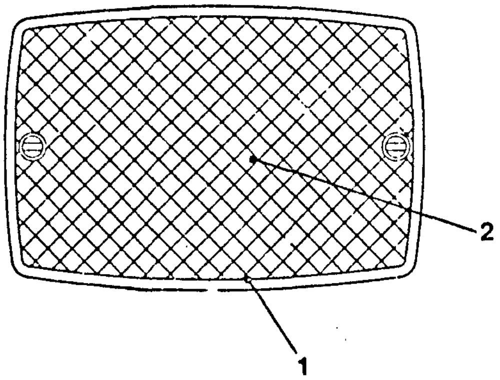


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7479	1	LENS
	2	844347	1	BULB
	3	844348	1	BULB

P815954
REV 001

815954 STOP / TAIL / DIRECTION LAMP
Part of 838835, 838833, 838832 and 838834 Road Lighting Groups

ELECTRICAL EQUIPMENT

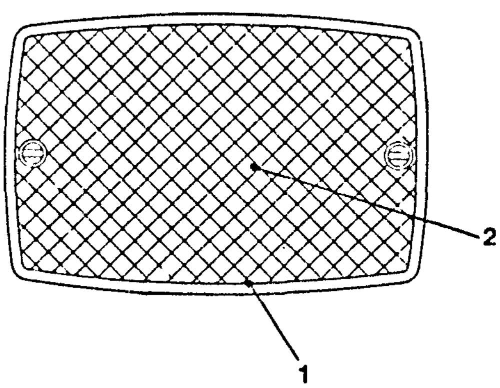


NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7477	1	LENS
	2	844347	1	BULB

P815957
REV 001

815957 REVERSING LAMP GROUP
Part of 838835, 838833, 838832 and 838834 Road Lighting Groups

ELECTRICAL EQUIPMENT

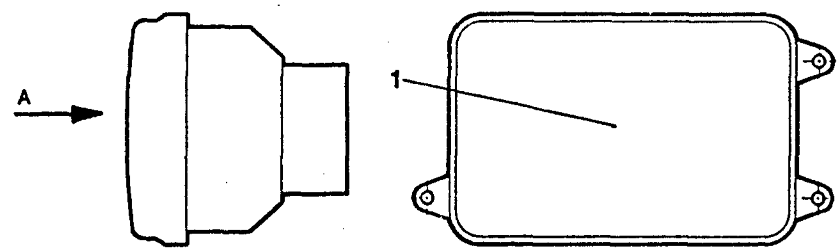


NOTE	REF NC	PART NUMBER	QTY	PART NAME
	1	6R7476	1	LENS
	2	844347	1	BULB

P815958
REV 001

815958 REAR FOG LIGHT GROUP
Part of 838835, 838833, 838832 and 838834 Road Lighting Groups

ELECTRICAL EQUIPMENT



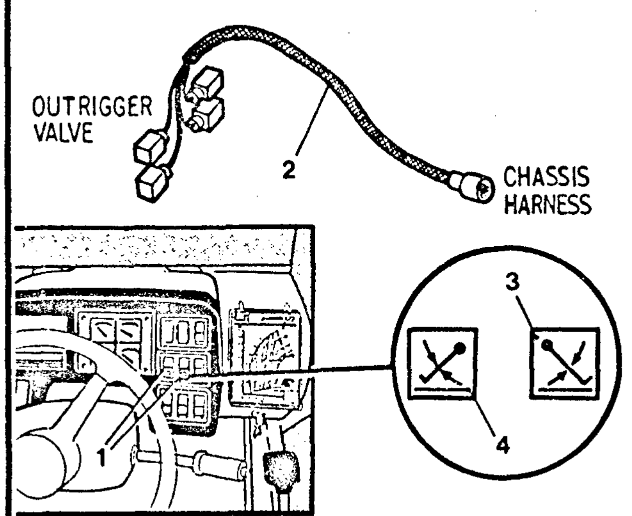
815980 HEADLAMP R.H. DIP				
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	844349	1	BULB

815979 HEADLAMP L.H. DIP				
NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	844349	1	BULB

815979--80
REV 001

815979 AND 815980 HEADLAMP GROUPS
Part of 815985, 815984, 815702 And 815701 Front Light Groups

ELECTRICAL EQUIPMENT (AN ATTACHMENT)



NOTE	REF NO	PART NUMBER	QTY	PART NAME
	1	6R7307	2	SWITCH
	2	6R8940	1	HARNESS AS. - OUTRIGGERS
	3	6R9014	1	PLATE R.H. OUTRIGGER
	4	6R9015	1	PLATE L.H. OUTRIGGER

P6R8997 Y

REV 001

6R8997 ELECTRICAL GROUP - OUTRIGGERS

MEMORANDUM

MEMORANDUM

DECALS AND CHARTS

NOTE	838805 RT80 PART No.	838807 RT100 PART No.	QTY	DESCRIPTION	LOCATION
	2H9357	2H9357	1	TAG - ANTIFREEZE	STEERING WHEEL
	369871	369871	1	FILM - HYDRAULIC OIL	TANK FILLER
	369872	369872	1	FILM - DIESEL	TANK FILLER NECK
	369875	369875	3	FILM – TRANSMISSION FLUID	AXLE LEVEL PLUGS / TRANS. FILLER
	372471	372471	2	FILM - FORK WARNING	EACH SIDE OF BOOM HEAD
	374929	374929	1	FILM - DO NOT OPEN	RADIATOR CAP
	374930	374930	1	FILM - OPEN INSTRUCTIVE	RADIATOR BURP BOTTLE
	385533	385533	1	PLATE WARNING (PARKING BRAKE)	PARK BRAKE
	539694	539694	10	METAL TACK FASTENER	PLATES
	551742	551742	4	FILM - TIE DOWN	TIE DOWN POINTS
	———	———	1	LITERATURE GROUP	SEE FACTORY NOTIFICATION LIST
	6R7530	6R7530	1	SHIFT PATTERN DECAL	STEERING COLUMN
	6R9271	6R9271	2	TREAD - ANTI SKID	HYDRAULIC AND FUEL TANK LIDS
	6R9272	6R9272	4	TREAD - ANTI SKID	L.H. REAR MUD WING
	6R9273	6R9273	4	TREAD - ANTI SKID	R.H. REAR MUD WING
	6R9352	6R9352	1	FILM PARKING BRAKE	NEXT TO LEVER
	836434	836434	1	FILM MFG BY D.J.I.	R.H. SIDE CAB WALL
	836955	836955	2	FILM CATERPILLAR	EACH SIDE OF BOOM
	836971	———	3	FILM - RT80	EACH SIDE OF BOOM TOWER / R.H. BOOM
	———	836972	3	FILM - RT100	EACH SIDE OF BOOM TOWER / R.H. BOOM
	844226	844226	2	TREAD - ANTI SKID	CAB
	8S7777	8S7777	1	FILM - PATENT (LIFT TRUCK)	LOWER R.H. CAB WALL
	8T1911	8T1911	1	FILM - WARNING (CLEARANCE)	CAB ROOF
	912278	———	4	FILM - TIRE PRESSURE	ABOVE TIRES
	———	912278	2	FILM - TIRE PRESSURE	ABOVE REAR TIRES
	916850	916850	2	FILM - HAND WARNING	HEAD PLATE No2 BOOM SECTION
	975347	975347	1	FILM - WARNING (JUMPER CABLE)	BATTERY COMPARTMENT LID
	NSS	NSS	1	PLATE - ROPS/FOPS	CAB ROOF
	975462	975462	1	FILM - OPERATOR WARNING	R.H. CAB WALL
	NSS	NSS	1	FILM - NOTICE(SHIPPING)	TANK SIDE
	NSS	NSS	1	PLATE IDENTIFICATION	R.H. SIDE CAB WALL REAR
	975516	975516	4	FILM - LIFT SYMBOL	CHASSIS LIFTING LUGS
	975518	975518	1	FILM - DRY AIR CLEANER	AIR CLEANER BODY
	975529	975529	1	FILM - FRAME LEVEL	REAR R.H.CAB SHELF
	975578	975578	1	FILM - BOOM CONTROL	BOOM CONTROLLER
	9X2442	9X2442	1	FILM - CATERPILLAR	RADIATOR COWL
	9X2451	9X2451	3	FILM - STRIPE	ENGINE COWL
	9X6664	9X6664	2	FILM - CAT	ENGINE COWL
	———	985536	2	FILM - TIRE PRESSURE	ABOVE FRONT TIRES
	8Q2741	8Q2741	1	TREAD - ANTI SKID	HYDRAULIC TANK COVER - FRONT
	8Q2742	8Q2742	1	TREAD - ANTI SKID	HYDRAULIC TANK COVER - REAR

REV 001

P838805 AND 07

ENGLISH DECAL GROUPS

DECALS AND CHARTS

6R7826 DECAL GROUP - FRENCH

F	385534	1	PLATE WARNING - PARK BRAKE
F	975519	1	FILM - DRY AIR CLEANER
F	975507	1	PLATE IDENTIFICATION
F	8T1946	1	FILM WARNING (CLEARANCE)
F	975348	1	FILM-WARN (JUMPER CABLE)
F	NSS	1	PLATE-ROPS+FOPS
F	975464	1	FILM-OPERATOR WARNING (FRENCH)
F	975511	1	FILM NOTICE - BRAKE RESERVOIR
F	975562	1	FLIP DUTY CHART INSTRUCTIONS
F	975570	1	FLIP DUTY CHART INDICATOR

REV 001

6R7827 DECAL GROUP - SPANISH

F	385535	1	PLATE WARNING - PARK BRAKE
F	975520	1	FILM - DRY AIR CLEANER
F	975508	1	PLATE IDENTIFICATION
F	8T1947	1	FILM WARNING (CLEARANCE)
F	975349	1	FILM-WARN (JUMPER CABLE)
F	NSS	1	PLATE-ROPS+FOPS
F	975465	1	FILM-OPERATOR WARNING (SPANISH)
F	975512	1	FILM NOTICE - BRAKE RESERVOIR
F	975563	1	FLIP DUTY CHART INSTRUCTIONS
F	975571	1	FLIP DUTY CHART INDICATOR

REV 001

6R7828 DECAL GROUP - ITALIAN

F	385537	1	PLATE WARNING - PARK BRAKE
F	975522	1	FILM - DRY AIR CLEANER
F	975509	1	PLATE IDENTIFICATION
F	8T1950	1	FILM-WARNING (ITALIAN)
F	975351	1	FILM-WARN (JUMPER CABLE)
F	NSS	1	PLATE - ROPS, FOPS
F	975466	1	FILM-WARNING TO OPERATOR
F	975513	1	FILM NOTICE - BRAKE RESERVOIR
F	975565	1	FLIP DUTY CHART INSTRUCTIONS
F	975573	1	FLIP DUTY CHART INDICATOR

REV 001

6R7829 DECAL GROUP - GERMAN

F	385536	1	PLATE WARNING - PARKING BRAKE
F	975521	1	FILM - DRY AIR CLEANER
F	975552	1	PLATE IDENTIFICATION
F	8T1949	1	FILM WARNING (CLEARANCE)
F	975350	1	FILM WARNING (JUMPER CABLE)
F	NSS	1	PLATE ROPS & FOPS
F	975543	1	FILM OPERATOR WARNING
F	975557	1	FILM NOTICE - BRAKE RESERVOIR
F	975564	1	FLIP DUTY CHART INSTRUCTIONS
F	975572	1	FLIP DUTY CHART INDICATOR

REV 000

NSS - NOT SERVICED

F - NOT SHOWN

FRENCH, SPANISH, ITALIAN AND GERMAN DECAL GROUPS

DECALS AND CHARTS

6R9174 DECAL GROUP - DANISH

F	978210	1	PLATE WARNING - PARKING BRAKE
F	975547	1	FILM - DRY AIR CLEANER
F	975554	1	PLATE IDENTIFICATION
F	8T1911	1	FILM-WARNING (CLEARANCE)
F	975536	1	FILM WARNING (JUMPER CABLE)
F	NSS	1	PLATE - ROPS & FOPS
F	975545	1	FILM OPERATOR WARNING
F	975559	1	FILM NOTICE - BRAKE RESERVOIR
F	975567	1	FLIP DUTY CHART INSTRUCTIONS
F	975575	1	FLIP DUTY CHART INDICATOR

REV 000

6R9175 DECAL GROUP - GREEK

F	978211	1	PLATE WARNING - PARKING BRAKE
F	975548	1	FILM - DRY AIR CLEANER
F	975555	1	PLATE IDENTIFICATION
F	8T1911	1	FILM-WARNING(CLEARANCE)
F	975537	1	FIM WARNING (JUMPER CABLE)
F	NSS	1	PLATE - ROPS & FOPS
F	975546	1	FILM OPERATOR WARNING
F	975560	1	FILM NOTICE BRAKE RESERVOIR
F	975568	1	FLIP DUTY CHART INSTRUCTIONS
F	975576	1	FLIP DUTY CHART INDICATOR

REV 000

6R7830 DECAL GROUP - DUTCH

F	978212	1	PLATE WARNING - PARKING BRAKE
F	975524	1	FILM DRY AIR CLEANER
F	975556	1	PLATE IDENTIFICATION
F	8T1911	1	FILM-WARNING (CLEARANCE)
F	975538	1	FILM WARNING (JUMPER CABLE)
F	NSS	1	PLATE ROPS & FOPS
F	975467	1	FILM OPERATOR WARNING
F	975561	1	FILM NOTICE - BRAKE RESERVOIR
F	975569	1	FLIP DUTY CHART INSTRUCTIONS
F	975577	1	FLIP DUTY CHART INDICATOR

REV 000

6R7831 DECAL GROUP - PORTUGUESE

F	978209	1	PLATE WARNING - PARKING BRAKE
F	975523	1	FILM DRY AIR CLEANER
F	975553	1	PLATE IDENTIFICATION
F	8T1948	1	FILM WARNING (CLEARANCE)
F	975535	1	FILM WARNING (JUMPER CABLE)
F	NSS	1	PLATE ROPS & FOPS
F	975544	1	FILM OPERATOR WARNING
F	975558	1	FILM NOTICE - BRAKE RESERVOIR
F	975566	1	FLIP DUTY CHART INSTRUCTIONS
F	975574	1	FLIP DUTY CHART INDICATOR

REV 000

NSS - NOT SERVICED

F - NOT SHOWN

DANISH, GREEK, DUTCH AND PORTUGUESE DECAL GROUPS

DECALS AND CHARTS

6R9176 DECAL GROUP - FRENCH (NACD)

F	385534	1	PLATE WARNING - PARK BRAKE
F	975519	1	FILM - DRY AIR CLEANER
F	975507	1	PLATE IDENTIFICATION
F	8T1946	1	FILM WARNING (CLEARANCE)
F	975348	1	FILM-WARN (JUMPER CABLE)
F	NSS	1	PLATE-ROPS+FOPS
F	975464	1	FILM-OPERATOR WARNING (FRENCH)
F	975511	1	FILM NOTICE - BRAKE RESERVOIR
F	975562	1	FLIP DUTY CHART INSTRUCTIONS

REV 000

6R9177 DECAL GROUP - SPANISH (NACD)

F	385535	1	PLATE WARNING - PARK BRAKE
F	975520	1	FILM - DRY AIR CLEANER
F	975508	1	PLATE IDENTIFICATION
F	8T1947	1	FILM WARNING (CLEARANCE)
F	975349	1	FILM-WARN (JUMPER CABLE)
F	NSS	1	PLATE-ROPS+FOPS
F	975465	1	FILM-OPERATOR WARNING (SPANISH)
F	975512	1	FILM NOTICE - BRAKE RESERVOIR
F	975563	1	FLIP DUTY CHART INSTRUCTIONS

REV 000

NSS - NOT SERVICED

F - NOT SHOWN

FRENCH (NACD) AND SPANISH (NACD) DECAL GROUPS

DECALS AND CHARTS

F	844160	1	FLIP DUTY CHART - INSTRUCTIONS
F	844235	1	FLIP DUTY CHART - INDICATOR
F	8Q2388	1	FLIP DUTY CHART - COSA STANDARD CARRIAGE
F	8Q2389	1	FLIP DUTY CHART - COSA TRUSS
F	8Q2390	1	FLIP DUTY CHART - COSA ROTATE CARRIAGE

F - NOT SHOWN

P838809

REV 000

838810 CAPACITY CHART GROUP - RT80 COSA WITHOUT OUTRIGGERS

DECALS AND CHARTS

DECALS AND CHARTS

F	844160	1	FLIP DUTY CHART - INSTRUCTIONS
F	8Q2385	1	FLIP DUTY CHART - U.S.A .STANDARD CARRIAGE
F	8Q2386	1	FLIP DUTY CHART - U.S.A .TRUSS BOOM
F	8Q2387	1	FLIP DUTY CHART - U.S.A. ROTATE .CARRIAGE

F - NOT SHOWN

P838809

REV 000

838809 CAPACITY CHART GROUP - RT80 U.S.A. WITHOUT OUTRIGGERS

DECALS AND CHARTS

DECALS AND CHARTS

F	6R9044	1	DUTY CHART - TRUSS BOOM (USA)
F	6R9079	1	DUTY CHART - STANDARD CARRIAGE (USA)
F	6R9080	1	DUTY CHART- ROTATE CARRIAGE (USA)
F	844160	1	FLIP DUTY CHART INSTRUCTIONS

F - NOT SHOWN

P838813

REV 000

838813 CAPACITY CHART GROUP - RT100 U.S.A. WITHOUT OUTRIGGERS

DECALS AND CHARTS

F	6R7710	1	DUTY CHART - STANDARD CARRIAGE WITH OUTRIGGERS UP
F	6R7711	1	DUTY CHART - STANDARD CARRIAGE WITH OUTRIGGERS DOWN
F	6R9044	1	DUTY CHART - TRUSS BOOM (USA)
F	6R9073	1	DUTY CHART- ROTATE CARRIAGE (USA) WITH OUTRIGGERS UP
F	6R9074	1	DUTY CHART- ROTATE CARRIAGE (USA) WITH OUTRIGGERS DOWN
F	844160	1	FLIP DUTY CHART INSTRUCTIONS

F - NOT SHOWN

P838815

REV 000

838815 CAPACITY CHART GROUP RT100 U.S.A. WITH OUTRIGGERS

END

FILMED

DATE: 4-93

DTIC